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WHY SUCCESSFUL STUDENTS OF THE NATURAL SCIENCES ABANDON CAREERS IN SCIENCE.

BY- NORDSTROM, CARL FRIEDENBERG, EDGAR Z.
CITY UNIV. OF NEW YORK, BROOKLYN COLL.

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THIS STUDY INVESTIGATED EXPERIENCES, PERCEPTIONS, AND EXPECTATIONS OF SCIENTISTS WHO ABANDON SCIENCE CAREERS. A CARD SORT WAS GIVEN TO 45 COLLEGE SENIORS AND RECENT GRADUATES WHO HAD CHANGED THEIR FIELD OF SPECIALIZATION FROM ONE TO THE NATURAL SCIENCES TO THE HUMANITIES OR SOCIAL SCIENCES. THE SUBJECTS SORTED THE CARDS ACCORDING TO CONVENTIONAL FORCED-CHOICE DIRECTIONS INTO A SYMMETRICAL 1-3-7-10-7-3-1 DISTRIBUTION, RANGING FROM THE CARD BEARING THE ONE BEST PIECE OF ADVICE TO THAT BEARING THE MOST MISLEADING PIECE OF ADVICE. FOLLOWING THE CARD-SORT, EACH SUBJECT WAS ASKED TO DISCUSS THE REASONS FOR SELECTING EACH OF THE FOUR CARDS HE HAD PLACED IN THE POSITIVE END AND IN THE NEGATIVE END OF HIS DISTRIBUTION. IT WAS FOUND THAT MOST OF THE STUDENTS WHO LEFT THE SCIENCES FOR OTHER DISCIPLINES WERE CONCERNED WITH PERSONAL SELF-INTEGRATION AND THE MAINTENANCE OF A HEALTHY SPIRIT OF INQUIRY, LEAVING ONLY A SMALL NUMBER OF SCIENCE MAJORS WHO HAD CONCERNS SIMILAR TO THE SIGNIFICANT GROUP OF THOSE WHO HAD LEFT. FURTHER STUDY IS RECOMMENDED TO FIND WAYS IN WHICH POTENTIALLY CREATIVE SCIENTISTS WHOULD BE SALVAGED. (JL)

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Brooklyn College
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Chapter I
The Problem

During the past several years there has been a great deal of public concern -- not all of it constructive or based on fully tenable assumptions -- at a presumed failure of American education to develop the scientific talent available in our country and needed for its welfare. Many young people who might become gifted scientists to the mutual advantage of the nation and themselves are, it is held, either never made aware of their potential or positively discouraged from developing it.

It is certainly true that many young Americans who possess characteristics that make them very promising as scientists either never undertake to train themselves as scientists or abandon the effort. This, in itself, may be no cause for concern; for society has need of diverse functions and gifted young people often have diverse gifts. Not everyone who would make a good scientist should seek to become one, either for his own sake or that of the community. But, certainly, those students who are sufficiently interested and able to have completed several years of scientific training successfully ought not to leave science for adventitious reasons. If their reasons for changing to another field are sound, they presumably made their initial choice on the basis of a substantial misunderstanding of what it would entail. The misunderstanding may have been of science as a field of study, or of the scientific establishment as a social institution, or of themselves and what they really want in life.

The difficulty, however, may be much less simple. We are none of us at twenty what we will be in middle life; the demands that a career makes on an individual are likewise very different in its preparatory and in its mature stages. Those students who change may in some cases be alienated from science by needlessly repellent, though real aspects of scientific training, even though their career choice was fundamentally sound. We do not know how often interested and able students abandon scientific careers because they actually gain more understanding of what their choice has meant, or whether, in contrast, they are influenced by educational experiences that they find unpleasant but that might easily have been avoided or that have very little to do with the probability that they will ultimately find great satisfaction in the life of a scientist or engineer.

Some of those who leave science in the early stages of their training may be just the persons who would have contributed most as mature scientists if they had continued in the field. It is even likely that precisely the quality that makes them most promising may make them the more easily alienated. Early scientific training emphasizes a rigor and discipline that may be necessary to the scientist but that becomes deadly in pedantic hands. The job opportunities that are easily visible from the position of a student offer little prospect of intellectual excitement or opportunity for creative independent research. Yet, the vitality of science depends wholly on the work of those scientists whose most fundamental satisfaction comes from spontaneous, though disciplined creativity.

In order to understand why a scientific career may be rejected by youngsters well qualified to pursue it, we must consider how science as a pattern of life is likely to look from where they stand. We must try to understand how science is likely to rank, among the other choices possible to them, as a potential source of the kinds of satisfactions that mean most to the kinds of people they already are.

There exists, actually, quite a large body of data that may be used in beginning such an analysis, but it has been collected for such different reasons and from such different points of view that it is difficult to synthesize.

The work of Roe,[1] Cattell,[2] Drevdahl,[3] and others has by now established quite a detailed picture of the American scientist, and of the way in which scientists differ from successful persons in other fields. The picture presented tends to be somewhat factorial rather than holistic -- the reader is likely to feel that he has been given a profile of personality traits and tendencies rather than a portrait of the scientist as a person -- but there is considerable agreement about the traits that characterize the American scientist: his endocathection and preference for abstract, symbolic modes of experience to direct interaction with other persons.

The pioneering work of Knapp[4] and his associates, and the more recent work of Holland[5] tells us something of value -- though far less than we need to know -- about where scientists come from, what kinds of colleges they choose for their training, and why they choose them. Havighurst and his collaborators, in many research investigations over a period of decades, have by now developed and richly explored the role of the school in the American status system, as has Riesman[6] by more subjective means. The justly celebrated and penetrating study of Mead and Metraux[7] of the "Image of the Scientist Among High School Students," while conducted on a large scale, provides extremely vivid insights into the different -- and often mutually contradictory -- levels of perception that simultaneously influence the behavior and attitudes of individual youngsters to the scientist and his life, and O'Dowd and Beardslee[8] have recently completed a comparable study, much smaller in scale but highly sophisticated in methodology, of the image held by college students of a number of selected professional roles, including especially that of the scientist.

In this study, we have attempted to discover what common experiences, perceptions and expectations of science are held by those who turn from it. We then compare these with the experiences, perceptions and expectations of a sample of advanced undergraduates continuing in science or engineering selected for excellence. For convenience, we shall refer throughout this report, to those of our subjects who have changed from the sciences to another field as our experimental group; and to those continuing in the sciences as our control group, although this usage is not strictly applicable to a procedure that, like ours, is comparative rather than experimental.

We did not expect to find, and have not found, any single or stereotypical pattern. We have found, as expected, that analysis of individual feelings about science and the life of the scientist does reveal certain characteristic differences between those who abandon scientific careers and those who remain in them; and that some of these differences are not quite what we anticipated. We have also found, as we expected, several groups of individuals which differ from one another in their prevailing attitudes toward and perceptions of a scientific career, but which are internally quite homogeneous in the way they see science. The structure of these groups, however, indicates that these attitudes have a rather complex influence on a student's decision to abandon science or to stick with it. For, while several of our groups are composed wholly, or nearly so, of students who have abandoned science; or wholly of students who are continuing in it, there are more clusters containing both students who have abandoned science and students who are continuing in it, even though the cluster was generated because these students tended to see science in the same way. When we turn to our interviews with students to explain this, it becomes clear that a student's conception of and feeling about himself really determines how his conception of science will affect his career choice.

Our study was designed to test the following hypotheses:

A. Students who have abandoned the study of science after having successfully completed several years of college-level training will tend, when examined by a suitable procedure, to fall into one of three groups:

(1) those who feel the most serious drawbacks to a scientific career to be conditions that they perceive as limitations on the free play of their integrity and spirit of inquiry. We have in mind such things as a conception of scientific method that excludes from consideration as data anything non-replicable or subjective; intrusions on the scientist's personal and political life by security programs; insufficient autonomy in planning work, or over-fragmentation of the individual scientific vision by the demands of large-scale, team projects;

(2) those who decide that they want more external rewards than they believe science will yield them: higher potential income, more personal power or status, a jollier peer group;

(3) those who expected science to be more directly concerned with human welfare and immediate problems of living than they find it to be; who expected to derive their principal career satisfaction from the experience of serving their clientele directly; who find it difficult to visualize the possible value of their work as simply an impersonal component of a process whose final human consequences they can never hope to see.

B. Students who have abandoned their career in science primarily for the reasons suggested in A(1) above -- that is, who are repelled by conditions that they perceive as limitations on their integrity and spirit of inquiry -- will resemble, in their total attitude toward science, highly successful students who continue their scientific work more closely than will those students who withdraw from science primarily for the sake of greater external rewards or of more directly rewarding interpersonal relationships.

Part (1) of hypothesis A is, we believe confirmed. The description in this paragraph fits a conspicuous group of the former science and engineering students in our sample. Hypotheses A(2) and (3), however, are not confirmed. The feelings and attitudes described in hypothesis A(2) seem to be both too naive and ideologically inappropriate for successful American college students today. Such ideas are expressed, to be sure, among others; but they are not the ideas that many successful young college students use to justify anything as important as their vocational choice in 1960. Our subjects tend to take money for granted, which makes it hard for them to take it seriously. They seem always to have had enough, and never enough to have experienced for themselves its remarkable capacity to induce sensations of security, euphoria and omnipotence. To a middle-aged observer they seem generally to rate money and power too low. Sociability, gregariousness and casually gracious living are also taken for granted; they are available -- sometimes too abundantly -- to scientists just like everybody else.

In contrast, many of our subjects attach great important to the issues mentioned under hypothesis A(3): satisfactions derived from the feeling that one is personally performing a service of direct human significance. But they do not tend to form a group distinct from those who insist on the significance of their subjective perception; because it is these who also express most need for human warmth and devotion to duties conceived as humane. The "mad scientist" isolated in his laboratory is a bad joke to students at this level of academic achievement and intelligence; the hydrogen bomb is seen as a problem not because science is brutal, but because statesmen and scientists are not competent as human beings. Throughout our interviews, among those who have abandoned science and those who are committed to it, the names of Albert Schweitzer and Robert Oppenheimer recur as authentic folk myths in their own lifetimes. Many of the respondents who cite these men as ideals are confused about the significant details of their careers. But what is striking is the moral maturity with which our subjects perceive them as significant;*through* their scientific achievements but *because* of their human qualities. Such young people see personal service as informed and even exalted by the spirit of free inquiry, and they would not think of choosing between them. There is enough of this feeling spread among the members of our sample to invalidate A(3). Indeed, one student spoke most lucidly and most profoundly of Schweitzer as illustrative of the moral function of science. He is continuing in science, *and is the only subject continuing in science* whose attitudes place him in the group mentioned above as supporting hypothesis A(1); the other members of this group have changed from science to other careers. This exceptionally gifted young man seems to have been preserved as a potential scientist in part by his very convication that science is a form of high personal service, even though he fully shares the awareness of the limitations of science as a total epistemology that helped drive other young people who were less interested in service out of the scientific field.

Our findings therefore provide no crucial test of hypothesis B, since no groupings of students who had abandoned scientific training for the reasons indicated under hypotheses A(2) and (3) emerged to be compared to the control group. But we think the reader will come to agree, on the basis of the whole tenor of our subjects' response, that hypothesis B should be rejected. What hypothesis B would mean, if confirmed, is that students who continue successfully in the exacting curricula of science or engineering tend to be supported in their progress by an unusually clear idea of who they are and where they are going; by a strong personal commitment to the goals of science broadly conceived in their full meaning. Such students would, then, simply as human beings, be more like those who leave science for deeply humanistic reasons than like those who leave for petty or superficial ones.

Our control group did not turn out to be much like that. It includes a variety of young men and women, many of whom will undoubtedly go on to be a credit to their profession. They are patient, good-humored, resolute and -- at least in the short run -- intelligent.

> They may remember
> The vision they have had, but they cease to regret it,
> Maintain themselves by the common routine,
> Learn to avoid excessive expectation,
> Become tolerant of themselves and others,
> Giving and taking, in the usual actions
> What there is to give and take. They do not repine.[9]

We have presented these hypotheses formally here at the outset, and have adumbrated our subsequent discussion of our findings by briefly indicating their fate because our study did, in fact, begin with these hypotheses and our procedure was designed to test them. We believe this to be sound as well as conventional procedure in social science methodology. But though we began with them, we certainly were not finished when we had tested them. The reader may or may not agree that our findings warrant the acceptance of hypothesis A(1) and the rejection of B, while providing no basis for the inferences suggested in A(2) and (3). But we think that some of our unanticipated findings may be more important than the fate of these hypotheses.

It is not so much that we are the beneficiaries of serendipity as that our hypotheses served us better as a crude and oversimple heuristic model than as empirical propositions. What seems to us central and original in our work is the insight that it yields as to the relationship between science as a social institution and the common values and personal purposes held by students as they respond to what they see in it. We have been studying what happens at the point of contact between the student as a person and the social framework within which he hopes, or had hoped to build his career. Our hypotheses specify certain of the processes which might be relevant to the interaction between the student and the scientific establishment, and they guided us in the design of an instrument and procedures by which this interaction might be studied. When it was, it proved, as usual, to be more complex than our procedure anticipated, but not, withal, unintelligible.

FOOTNOTES TO CHAPTER I

1. Roe, Anne, The Psychology of Occupations, New York, Wiley & Sons, 1956.

2. Cattell, R. B., and J. E. Drevdahl, "A Comparison of the Personality Profile (16 p.) of Eminent Researchers with that of Eminent Teachers and Administrators, and of the General Population," British Journal of Psychology, XLVI, 4, November, 1955.

3. Drevdahl, J.E., "An Exploratory Study of Creativity in Terms of its Relationship to Various Personality and Intellectual Factors,"PhD dissertation, University of Nebraska, Lincoln, 1954.

4. Knapp, R. H., and H. B. Goodrich, Origins of American Scientists,Chicago, University of Chicago Press, 1952.

5. Holland, John L., "Undergraduate Origins of American Scientists," Science, 126, September 6, 1957.

6. Riesman, David, Constraint and Variety in American Education, Lincoln, University of Nebraska Press, 1956.

7. Mead, Margaret, and Rhoda Metraux, "Image of the Scientist Among High School Students -- a pilot study," Science, 126, August 30, 1957.

8. O'Dowd, Donald D. and David Beardslee, College Student Images of a Selected Group of Professions and Occupations, Wesleyan University, July 22, 1960, U.S. Office of Education, Cooperative Research Project, #562 (8142)

9. Eliot, T. S., The Cocktail Party, New York, Harcourt Brace & Co., 1950, p. 139.

Chapter II
Collection of the Data

We did not undertake to assess the personality of our subjects, nor did we attempt to place them along any set of scalar traits or dimensions. We hoped, rather, to identify clusters of individuals who define themselves as similar in their expressed perceptions of a scientific career, who have noticed similar things and had similar feelings about specific aspects of their training experience. We created these clusters statistically by the application of Stephenson's Q-technique, and we shall interpret them on the basis not only of the pattern of card choices that produced the clustering but also of recorded interviews with each subject in which he discussed freely his reasons for having chosen those cards on whose importance he lays most stress. Each of the cards states a cautionary reason why an individual might not wish to be a scientist and these reasons are so stated as to refer very specifically to a wide variety of issues related to our hypotheses. Our clusters then reflect the subject's perception of his experience as a science student, and a wide sampling of the things about that experience that became important to him.

Our data yield an image of the scientist as a sample of college upper-classmen and recent graduates see him. But they also tell us a lot about the subject's self-image, as this is related to his picture of the scientist, and his feelings about the relationship. This is the core of our research problem.

Our general method was a fairly conventional application of the Q-techique of William Stephenson.* Our subjects were asked to sort a set of 32 cards, each of which bears a statement that they are directed to consider as a piece of cautionary advice that they might wish to give to a younger student who was seriously considering becoming a scientist. The card statements were to be regarded as factors that they feel the younger person might take into consideration before finally committing himself to a scientific career. Subjects sort the cards according to conventional forced-choice directions into a symmetrical 1-3-7-10-7-3-1 distribution, ranging from the card bearing the *one best piece of advice* to that bearing the *most misleading piece of advice*. The directions are reproduced as Appendix A and the card statements as Appendix B. Two subjects out of 121 declined to complete the sort because they felt that the distribution of the statements they would have been forced to make would very seriously distort their actual feelings about the cards.

Immediately following his card-sort, each subject was asked to discuss his reasons for selecting each of the four cards he had placed in the positive end, and in the negative end of his distribution. (The two students who had refused to complete the sorts were interviewed in this way also since they had no difficulty in identifying eight *extreme* cards.) We also asked them to discuss any other pertinent issues that they might have wished to bring up in an unstructured interview, but that none of the card statements touched upon. These interviews varied greatly in length, from a quarter of an hour to about an hour, with a usual duration of about twenty-five minutes. Most were individual interviews, but in several cases joint interviews were held with two subjects simultaneously; in some of these, one respondent was a member of the experimental group and the other of the control. In general, the joint interviews touched on more interesting issues than the individual ones. The presence of another student seemed to stimulate deeper and more dialectical discussion.

Our sample was drawn from three institutions: Brooklyn College, Ohio State University and Stanford University. Its composition is reported in Table I.

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* Stephenson, William, *The Study of Behavior*, Chicago, The University of Chicago Press, 1953.

The interviews make it clear that the Old Pros and the Conventionals are not really vigorous in their advocacy of these cards; instead, they are just trying to be helpful. Members of the two clusters feel that some of these cards raise valid points related to the amenities of living and should not be ignored out of idealistic fervor. They do not feel strongly about the matter, though, and generally maintain, in the words of Mr. Jones, that they "have no real torch to carry here." Mr. Wheeler expresses what to all indications is the general attitude:

> **WHEELER:** Well, I think, in general, expressing what a lot of the cards stated, although maybe not specifically, was that more than anything, the person should be sure that he would be contented with what he was doing.

Those standing with the conjectural A(1) beg to differ. They can be extravagant in their critique or cool and collected, but they are consistently negative. For instance, Mr. Bond says: "I really don't care how rich I'm going to be," and Mr. Tudor adds: "I would be miserable making lots of money doing something I couldn't stand." And, standing at the other end of the attitude spectrum, the Cool Mr. Cimarosa comments:

> **CIMAROSA:** I don't think it's (money) an important thing to shoot for, because I think that if you are going for just the money part of it, that you'll never make it.

Many of the subjects with the Adolescent orientation reject practical advice with almost too much enthusiasm, possibly for reasons not unlike those they gave for rejecting the scientific method as they had experienced it. They are just as concerned with avoiding the clammy grip of mundane greed as they are with avoiding the dead hand of the method. They seem to feel both are encroachments on their person, and they are, above all, concerned with maintaining their self uncontaminated. Those who, on the other hand, have accepted science as a way of life, are properly interested in what it has to offer. Nevertheless, they are not eager, and therefore do not stand especially close to the conjectural A(2). But they are shrewd enough to be wary about the details of compensation.

The second sub-pattern to be noted contributes some heterogeneity to the pattern of relationships developed so far. Cards #8 and #21 refer to the kinds of people scientists are. The subjects as a whole would seem to stand with A(1) and #8 and #21 are among the most unpopular of all cards. There are, however, two important exceptions to this rule. The Societal and the Cool, which are generally associated with the A(1) point of view, are very positive in recommending these cards as important advice to be given a potential science student. Mr. Byron, Mr. Swanson, Mr. Cimarosa and Mr. Gundig all have previously expressed themselves at length on these cards and not much more need be said. A few words from Mr. Byron, who placed #8 first and #21 second, should suffice:

> **BYRON:** I have known scientists. My father is a scientist, and I've known quite a few of his friends and this card #8 is very important for those people. They tend to be very dull and very narrow-minded and literal-minded with very little, it seems to me, expression. Engineering, you have more expression. Engineers have more expression than scientists. ... It's different, really, for engineers. I'd find engineers also probably a little bit dull, but not because they are narrow-minded and scientific, but because they tend to think in terms of, well, fun to them is barbecues and picnics and bowling and well, not much expression in political interests or artistic interests. Scientists probably have more interest in the fine arts than engineers and have very little interest in barbecues. I think scientists aren't interested in people. They're not interested in being good fellows. They're interested in science. And engineers are interested in being good fellows.

humanities or social sciences at a time when he was doing well enough to continue if he wished to come in and spend about an hour at a single session on our card-sort and subsequent interview. No payment was offered to the subjects; only about thirty per cent responded. A follow-up letter proved virtually ineffective in bringing in subjects who had ignored our first letter.

Members of our control group were nominated by department chairmen in the sciences. We asked each chairman to give us the names of three students whom they would consider best representing the work of their department; we then wrote them directly about two weeks before the end of the school year. None of these ignored our request; all either came for the card-sort and interview or wrote to explain that they were working and had no time to come in to the college and meet with us before the end of the school year. Because the control-group subjects were so much more cooperative than the experimental group subjects, we ended up with an equal number of each, though we had written to many more experimental group subjects.

At Ohio State, most of the experimental group subjects were identified by scanning the records of all seniors scheduled to graduate during the academic year 1959-1960 from the Colleges of Arts and Science, Commerce, and Education, which together include all the departments generally included among the social sciences or the humanities. Criteria for inclusion were the same as those for Brooklyn College. The records of graduate students at Ohio State University are not filed in College offices but in departmental offices, and it was not practical to gain access to all these during the time available for collecting data at Ohio State. Only in the department of education, where the study was widely known and generally accepted were graduate experimental group subjects identified by formal inspection of their records. Others were referred informally by individuals interested in the study who knew recent graduates who fit our criteria. One undergraduate subject referred himself after hearing one of the authors describe the work to a class he was attending. This student had transferred from an Eastern university too recently for his Ohio State record to indicate that he belonged in the study.

Control group undergraduate students in the sciences were identified by formal inspection of their records, which were on file in the College of Arts and Science. At Ohio State, however, unlike Brooklyn, there is an Engineering curriculum. A large proportion of students now in social science or humanities who were formerly interested enough in science to prepare for a scientific profession had begun in engineering rather than in pure science. We needed a control group of engineering students; these were nominated by the Dean of the College of Engineering, who worked down a list in descending order of grade point average, of students currently enrolled, selecting those students whom he thought most creative and interesting and skipping many names which he regarded as merely conventionally -- though highly -- successful. All these were either undergraduates or students completing the final year of a five-year Master's degree program.

Ohio State subjects were paid two dollars to participate. Thirty-four of the fifty-three experimental group subjects invited to participate did so -- about twice the proportion as at Brooklyn. As in Brooklyn, the use of a follow-up letter failed to bring in additional subjects in any number. Only 26 of 72 control group students accepted our invitation to participate. We believe that the most plausible reason for this contrast in the cooperativeness of the Brooklyn and Ohio State control groups is simply that Brooklyn College seniors who are doing excellent work are exempted from final examinations and therefore had more time to meet with us; the Ohio State control group was approached close to the end of the winter quarter when they were under considerable pressure to prepare for final examinations.

The Stanford sample were selected somewhat differently. Stanford students are permitted to indicate a choice of major early in their college careers, and changes are frequent. We began by checking all changes of major filed during the past four years, then checking records of all those students who had changed from natural science or engineering to social science or humanities. Sixty students who met the criteria for inclusion in the experimental group were identified. Since, however, we were able to identify all these in a single four-day period at the beginning of our work at Stanford in contrast to the situation at Ohio State where records were decentralized and filing procedures variable, we were able to rate our students at the outset into four groups of fifteen in descending order of our interest in them. We preferred students who had changed from science or engineering after long, rather than brief contact with them; who had better rather than average grades, or who had some curious feature in their records -- such as many changes or change from science to a highly contrasting field like music. We mailed our letters out first to the groups in which we were more interested so that they would have a longer time to respond. Subjects were paid two dollars as at Ohio State; no follow-up letter was sent. Thirty-one of the sixty were interviewed; twenty-one did not respond; while the eight remaining acknowledged the request but were unable to schedule appointments during the short time we were at Stanford.

Control group students at Stanford were obtained solely from academic records, making use of a list of all undergraduate students in descending order of grade point average, and inviting the highest of the science and engineering majors. Eighteen were invited; ten responded.

The distribution of grade point averages on the customary four-point scale of students included in the study for all three institutions combined is presented in Table 2.

Table 2

Distribution of Grade Point Average at Time of Study

(Four records unavailable, three of these are of subjects who were awarded Bachelor's degrees in one of the sciences.)

	Experimental	Control
2.0-2.19	5	
2.2-2.39	9	
2.4-2.59	13	1
2.6-2.79	11	1
2.8-2.99	10	2
3.0-3.19	9	4
3.2-3.39	5	6
3.4-3.59	5	11
3.6-3.79	-	17
3.8-4.00	2	4
	M=2.78	M=3.49
	N= 69	N= 46

For purposes of comparison, 46 Ohio State non-respondent controls have a GPA of 3.35; 19 Ohio State non-respondent experimentals have a GPA of 2.64. Eight Stanford non-respondent controls have a mean GPA of 3.35 also, while 21 Stanford non-respondent experimentals have a mean GPA of 2.79 -- virtually identical.

The composition of the experimental and control groups in various other respects is indicated in Tables 3, 4, and 5.

Table 3
Initial Major of Subjects

	Experimental	Control*
Physics	4	6
Zoology	13	6
Chemistry	4	7
Geology	1	5
Mathematics	8	2
Anatomy or other pre-med special major	2	3
Psychology	1	0
Undeclared	1	0
Total Science	34	29
Engineer	41§	17

* The final major of control subjects is, of course, the same.

§ In this table, the Brooklyn College pre-engineer is counted as an engineer.

Table 4
Distribution of Quarter-Hours Completed at Time of Study

	Exp.	Cont.	Sci.	Eng.
0- 90	0	3	0	3
90- 99	2	0	1	1
100-109	0	0	0	0
110-119	4	0	1	3
120-129	11	1	4	8
130-139	5	0	3	2
140-149	0	2	1	1
150-159	0	2	1	1
160-169	2	8	9	1
170 and over	49	30	43	36
Total	73	46	63	56

Table 5
Distribution of Quarter Hours Completed at Time of Transfer, Ohio State Experimental Group

QHC	Sci.	Eng.	TOTAL
0- 90	1	5	6
90- 99	0	5	5
100-109	2	2	4
110-119	0	1	1
120-129	1	4	5
130-139	0	2	2
140-149	0	2	2
150-159	1	0	1
160-169	0	0	0
170 and above	5	3	8
Total	10	24	34

Chapter III

The Subjects

One hundred and twenty-one subjects, drawn from three institutions of higher learning (twenty from Brooklyn College, sixty from Ohio State University, and forty-one from Stanford University) were interviewed. Ideally, they represent a cross-section of the population of highly able students in American colleges who are potentially creative scientists. Actually, they are the somewhat self-selected group that satisfied the operational criteria established for the study.

In our investigation, we encountered much more variety in our subjects than could possibly be incorporated in this report. For example, three of the subjects are foreign students, and two are Puerto Ricans; these two sorted their cards atypically. The Puerto Rican subjects were Ohio State students, had the same major and were placed statistically together but as isolates from the group as a whole. Thus, they appear in the findings as an odd little cluster situated alone somewhere in the outer reaches of experimental space. However, the card placements of the three foreign students were more conventional, and did not suggest that there is any special "foreign" position.* There is also the student who managed to complete his sort and interview before the interviewer discovered that he did not conform to the grade criterion. Interestingly enough, though, he dropped out in the course of the statistical processing, and is not recorded either as a member of a cluster or as an extreme isolate. Actually, there is little evidence that much of the variety characterizing the subjects distorts the findings. The statistical technique selects subjects for analysis whose way of life is not greatly different from that conceived of in establishing the operational criteria. And these representative men and women are the majority of the subjects.

However, there are two problems with our criteria which cannot be ignored. In Chapter II, we stated as qualifications for the experimental group that the subject should have shown some promise in the major field he had chosen and that he had made his choice to leave that field himself, and as qualifications for the control group that the subject be a model student. This implicitly accepts the rather conventional assumption that students who perform well in college are more likely to succeed as creative scientists than those who do not. And yet operationally, it places a heavy burden on grades in selecting subjects. This is the first of the two problems which we will examine for the remainder of this chapter.

For the second problem, we must turn again to the qualifications set down in Chapter II. Therein, we state that the subject must have been seriously committed to a career in the natural sciences or engineering. But the subjects themselves tell a very interesting story of the nature and substance of their commitment, and for this reason, we will also consider the problems they raise about self-definition in some detail in this chapter. For, the ideal image of the passionately concerned student seeking his career is simply too naive to be retained.

Grade Average as an Index of Potential

To be included in the sample, it is necessary for a student to have performed well in class. And yet, in designing the study, we have already recognized, as one possible reason for leaving science, dissatisfaction with the conventional training program. Card #23, for example, states, in part, that "scientific training actually seems to offer little encouragement for independence of thought. There is more lecturing and less discussion than in other disciplines." And card #17 suggests further that: "Most scientists spend most of their time in rather dull, routine activity." To the investigators, these cards represent one possible description of the circumstances surrounding a natural science education. Should a student feel this way and react accordingly, he would more likely than not suffer the consequences implicit in his reaction. And one of the more prominent of the possible consequences of a negative attitude towards the experience would be low grades. For it seems only reasonable to postulate that the grades received would be directly related to the student's response to his experience in the classroom. In this way, then, a rigorous application of a grade standard in subject selection would tend to remove from the lists legitimate candidates for the study. This being the investigator's position, let us now turn to the students and see what they have to say.

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* The problem with science education may be international in scope. T. Cottrell expresses dissatisfaction with British university training in science in his talk on the Third Programme. T. L. Cottrell, "Scientists: Real or Imaginary?" The Listener, Aug. 25, 1960.

> I was thoroughly disgusted with the things that we had to study and the lecturing. ... I didn't like the courses that they made us take. It could be that I didn't have the right attitude, because since I got out of science, I got married and got a little better attitude towards school, and maybe that would change if I was back in it, but at the time, I didn't ... I didn't like it.

This was Mr. Stevens, a student at Ohio State and one who, since transferring from engineering to the School of Commerce, has achieved a 3.7 cumulative average in his work. After a question by the Interviewer, he continued:

> **STEVENS:** Well, in high school I got by exceptionally well, doing not much work, and I got into college, I ... eighteen, didn't particularly care too much, didn't realize what was there, and I didn't study like I should. And, of course, part of that was due ... because I didn't like what I was studying: the theory behind it all. I was more for the practical part of it, and the more examinations tended towards theory, the less I liked them. And it finally got to the point where I flunked a few courses, got in some disciplinary trouble because I spent more time on my own than doing the work that I should have been doing.

In a more defensive spirit, Mr. Murphy, also of Ohio State, protested: "I think I could have made it ... I know I could have made it through engineering if I'd been interested enough, but when I lost interest, I just didn't have it. My grades dropped and there just wasn't anything there for me."

At Brooklyn, Mr. Dove also reacted to class experiences, but for reasons exactly opposite to those of Mr. Stevens:

> **DOVE:** When I came to Brooklyn College, I was very disappointed by the fact that when you actually go into the sciences you're more concerned with the practicalities in the sciences. ... What you actually find are percentage errors that you have to work out rather than thinking about broader aspects of science per se. What I actually enjoyed in science was pure math. Once I had to tackle this laboratory experiment which had small percentages of error. I became disgusted with it, and I dropped out.

Dove, whose grades in all mathematics courses were B or better, graduated with an average of 2.85 and, in addition, was awarded a teaching fellowship by the State Board of Regents.

Finally, for an almost classic statement on how one goes about undermining college cumulative grade point average, we have Mrs. Todd, a research assistant in the mathematics department at Ohio State. At the time of the interview, Mrs. Todd was employed by the University to teach Freshmen remedial mathematics. In her interview, she answered a question as to why she had left engineering, as follows:

> MRS. TODD: Well, I think probably I tried to take too many hours. At the time I was in engineering, they were changing from the four-year to the five-year scheme and in order to become a sophomore by a certain time, I took too many hours and I missed out on my calculus. And without calculus, you just stumble along after that. I think that was probably the reason. Actually, I left school to be married, but I wouldn't have been married if I had been happy in my college work.
>
> INTERVIEWER: I see. When you say "stumbled along," you mean that you never took calculus, or you don't ...
>
> MRS. TODD: No, I took calculus. But the quarter I was taking calculus, I was also taking many other hours that I never put the time in calculus. So I got a D the first quarter, and then, instead of repeating it then, I went on and I failed it the next quarter. I never really did get the fundamentals of calculus.

The Interviewer, remembering Mrs. Todd's present position with the University, could not resist the impulse and asked, "And yet you were apparently doing well enough that the math department would hire you to come back and teach Freshmen?"

> MRS. TODD: Yes, well, I had good grades. I mean, I could have gotten calculus. It was just that I was taking too many hours. I wanted so badly to become a second quarter sophomore by a certain quarter so that I could graduate in four years instead of five that I didn't repeat the calculus when I should have, and I went on and tried to build on something that I didn't have a foundation for.

At this point, the Interviewer, sufficiently confused, asked Mrs. Todd to explain the relationship between her uncertain feelings, her program in engineering, and her marriage:

> MRS. TODD: Well, that's a long complicated problem. I mean, at that time, my husband was to be graduated from college and I had received very poor marks that quarter and he said: "Well, let's just get married this summer." And I agreed, otherwise I wouldn't have agreed to it. If I had been doing well, I would have gone on.

This terminated this phase of the discussion with Mrs. Todd. Obviously, she was very much at odds with herself at this juncture in her academic career, and her grades, as well as much else that concerned her were at the meccy of her tormenting mood.

Whereas Mrs. Todd is exceptional in the degree to which she responded to her circumstances, she is still rather representative of the process by which many students who find themselves out of sympathy with their environment go about reaching a decision.

There is no simple, static relationship between the student's grade index and his general outlook. This must reduce the utility of grades as a suitable means for measuring potential, and secondarily, as a suitable means for selecting subjects. To what degree any cumulative grade point average represents a performance at the top level of the student's capacity would be difficult to determine. Certainly, any such index is affected by the personal conflicts and concerns of the student measured.

While it is clear that such concerns as these interfere with the student's ability to function in terms of his own best interest within the academic environment, it is equally possible for anxieties to lead to overachievement. The student who feels compelled to perform well may be forced by his conflicts and concerns to have a high grade point average, and this average may represent little more than an over zealous reaction to authority.

The student's grade performance, whether high or low, is bound up with his whole outlook. For this reason, the cumulative average can never be an ideal index of the student's creative potential in the natural sciences. However, it is important as the only objective index readily available to the experimenter and administrator. As investigators, we have had to depend on grade indices as a basis for selecting subjects for this study in the absence of any entirely satisfactory means.

The Meaning of the Term "Scientist"

The study proceeds on the simple assumption that a student majoring in a natural science has clearly in mind a career that can be defined by the term "scientist." However, by its very inclusiveness and sentimental implication, this term blandly obscures the wide range and variety in the meaning to the subjects themselves of the choice each has made. Actually, the evidence collected through the interviews suggests that very few students go to college planning to become a "scientist." They are very cautious with such an exotic idea and instead choose conventional terms such as doctor or engineer to describe their ambitions and let it go at that.

"When you're in high school," says Mr. Moreno of Ohio State, "everybody dreams of being an engineer. The majority of the fellows do." And Mr. Cimarosa, also of Ohio State, commenting on how he made his career choice, says:

> CIMAROSA: Engineering? Well, I think I was influenced by my parents. My father say ... my father always talked about when I was going to be an engineer. I was always good in math and science in high school. Actually, we really didn't give any other consideration as to what engineering did in the end. I just though it was a logical choice.

Procedurally, the study requires that the subject being interviewed imagine that he is participating in a discussion with a younger person who is planning a career in science. Some who saw themselves primarily as engineers, balked at this point, and maintained that they couldn't imagine themselves as scientists, or as persons giving advice about science. Mr. Dean of Brooklyn, for one, states this position quite clearly:

> DEAN: I wasn't going into pure science. I was going into engineering.

A moment later, he adds:

> DEAN: I didn't have much trouble with math or science and because of this and because of the high salaries that were being paid to electrical engineers, I thought that this might be very nice.

And Mr. Hyde of Ohio State, explores the distinction between "science" and engineering more thoroughly. In his interview, he had the following to say:

> **HYDE:** I noticed throughout the cards the term "scientist" was used. Now this to me was a little bit misleading, and then I don't know what a scientist is. You mentioned engineering. Now, engineering perhaps would be a better term to use, because I really don't think there are too many pure scientists, as it was presented in those cards. In other words, I got the impression by reading through the selection that your idea of a scientist is someone who sticks to theoretical stuff, he's stuck in a lab. I don't know how to describe it, but it seems to come from an idea of about a 1930 movie where the guy is sitting around with test tubes and he blows himself up once a week -- something like this. And this, I think, has passed out of the picture. I don't think you will find this class of people floating around. Now, there are people doing research in industry and government, but I don't think you'll find this stereotyped individual in too much quantity. I mean, there are undoubtedly a few around like that, but this is drawing the picture a little bit lopsided.

Mr. Rush of Ohio State describes more succinctly the dilemma of self-definition as follows:

> **RUSH:** I classify academic research as experimental research and industrial research as developmental research. Now, there is a difference between the two. Industrial research is, more or less, someone has devised something and you are to better it, make it more feasible, more economical. In other words, make it pay for the company. In the university, the experimental research is going along generally untried fields, to find something that might be of value either to yourself, to your fellow professors or perhaps to the country as a whole, although that is not important. That's why I considered a difference between the two.

When the Interviewer raised a question as to what effect this distinction would have on the cards chosen, Rush continued:

> **RUSH:** Well, several of these cards ... yes, I decided as to which I considered the more important question to ask. Several of those I judged as a professor would judge them. Others I judged as a worker of the industry would judge them.

And for one final statement in regard to this distinction, we have the observation of Mr. Keane of Ohio State:

> **KEANE:** I don't think there's such a thing as pure research in most of the research jobs that you get into. For instance, I was working on an Air Force project. Well, you look for what they want you to look for, and it seems as though perhaps something's overlooked there.

There is the need to make this distinction between science and engineering, with an emphasis on engineering as an appropriate career for one who has done well in mathematics and science in high school. This need is strong on the part of Ohio State students and especially for members of the control sample drawn from that institution. The problem doesn't seem to bother Stanford students as much, for they rarely bring it up. It may be that they are more secure in their belief that they can think of being scientists.

For Brooklyn, the problem of career definition in terms of "scientist" versus engineer is obscured by the structure of the curriculum. There is no engineering school at the College. Interested students planning a major in engineering transfer after two years to another college of The City University where they can continue their program. This makes it likely that the sample from Brooklyn would only include students whose objective had from the beginning to be identified with so-called pure science, such as chemistry and biology. In fact, the aforementioned Mr. Dean is something of an anomaly in that he had already transferred both out of and back into Brooklyn.

Another problem in self-definition concerns a distinction between "scientist" and mathematician. Mr. McMennan, for example, an Ohio State control, says:

> **MCMENNAN:** I'm majoring in math and so I don't know how closely you'd classify that to be a ... you wouldn't classify it as a laboratory or a social science.

And then a moment later adds:

> **MCMENNAN:** Most of these questions apply to a laboratory scientist.

However, as his statement about social science indicates, McMennan was not a very dependable subject, and might well have been simply confused. But Mr. Locke of Stanford, confirms the difficulty in self-definition later by his statement:

> **LOCKE:** I never really did consider myself in science, to be specific. You know, I mean, mathematics, and I always set that partly aside, because I was interested more in the theoretical mathematics than in the sciences.

In addition to the engineers and mathematics majors who consider themselves only vaguely to be "scientist," there are the students who regard public education as their primary area of concentration. Mr. Cole of Brooklyn, for example, says: "Although a physics major, I had decided to teach in high school." And Miss Pearl, also of Brooklyn, summarizes her comment on the general validity of the card-sort by saying:

> **PEARL:** I don't think that the cards were the main reason. Mainly, it was the family and the fact that teaching is more lucrative and that was my prime concern. Although I did go into teaching, I still kept up the science because I was so interested in it, and, as a result, I am graduating with a BS in Biology.

In her comment, Miss Pearl has touched on not one, but two of the problems in career self-definition. By the reference to family, Miss Pearl did not mean her parents. Instead, other sections of the interview indicate that she planned to get married and wanted a career that would help her support her husband. Marriage as an eventual possibility is, then, the fourth significant factor interfering with a consistent conception of a scientist. When Miss Matthews of Stanford was asked whether things would be difficult for a woman in the field of physics, she answered: "I think probably they would be for the simple reason that, well, women have a tendency to go off and get married, so people hesitate to hire them." And Miss Levine of Brooklyn, reverses the position taken above by Miss Pearl with regard to the kind of occupation a girl should prepare for. When, in discussion of card #1, she says: "This deals with the money aspect. ... As a woman, I don't feel that this is too important, because I know that I'll be provided for and I would want to enjoy my work rather than worry about the money I was going to make."

Finally, in matters of self-definition, are the medical and dental students. Are they to be considered scientists or not? In some cases, it is easy to decide, as in the case of Mr. Larson of Ohio State. When asked whether he was considering private practice, research, or what, Larson, a dental student, answered: "Well, right now I'm thinking of a combination of a private practice and teaching-research. I'd like to get a graduate degree in physiology as well as in medicine." More vaguely, but still within the realm of consideration, is Robert Burke of Stanford, who says: "I may go into research and I may not. It sounds interesting, but I really don't know."

However, to complicate matters, several self-acknowledged pre-medical students showed up as members of the experimental group. They were listed in the files as persons who had been biological science majors and changed; yet, when interviewed, they maintained that they had not changed their basic objective. Instead, they had decided to use their undergraduate time exploring the liberal arts curriculum. In regard to this, Mr. Harcourt of Stanford, says: "In my case, perhaps, the change is a little bit misleading because I had been pre-med, trying to go to med school and have never really given up that idea." On the other hand, he also mentions that he may be drifting further from that career choice now that he is taking courses in liberal arts. When asked whether or not his orientation in the field of medicine represented something less than that of a research scientist, Mr. Harcourt answered:

> HARCOURT: Yes, I would say so. I feel also that for something where ... medicine is considered a scientific field, perhaps, but where it's not, where there's a larger human element, certainly than in the other sciences, that such an intensive preparation, at an undergraduate level, aside from being unnecessary is, I feel, even rather unfortunate and perhaps a disadvantage in the long run.

William Heath of Stanford, echoes Harcourt's view with the following: "It isn't actually so much a real dislike for science as it is an opportunity to study some subjects which I won't be able to study so much later when I do get into science as such." And Arthur Friendly, also of Stanford, adds: "I would say that the big reason is the fact that I thought that going into medicine, you tend to become narrow in your interests, especially for the medical school years. You're confined to a certain area and I wanted to develop some sort of interest in another area so that eventually I could pursue that when I had more time."

Variety and ambiguity characterize the actual career definitions of many of the members of the sample. Where a young man of ten or twelve may be certain that he wants to be an astronaut or to disentangle bundles of atomic-sized particles, he is more than likely to become less sure as he grows older. The fundamental complexity of the career choice he must make, combined with the awareness that he has, at best, very little of the data needed for an intelligent decision press in upon him intensely during his college days. He begins to realize that the easy choice of earlier years takes on a kind of ominous specificity that cannot be neglected. In its totality, there is a moral choice, an occupational choice, and an educational choice to make. Is he to be a humanitarian? a technician in a laboratory? or a great discoverer? Will he earn enough and will he be respected at what he is doing? And is it worth the sacrifice to win the prize?

As the college student is perched on the edge of his decision sees it, to be a scientist in the most total sense involves working for an academic institution and probably parsimony; to be a mathematician involves an intensive concentration on a special language that has limited application; to be an engineer involves detail work and routine within a hierarchy; and to be a physician involves an expensive, old-fashioned education purchased under conditions that would probably only be satisfactory to a medieval monk. This is no simple thing for anyone, especially a youngster, to understand. For young women, the question of marriage and the woman's role bulks large and cannot be disregarded. For the experimenter to ask conscientious students to suspend judgment for the moment and to treat their outlook as if it were something simple, as if they were still sixteen, is demanding a great deal. And this, in effect, is what is done when the subjects are asked to consider the cards as pieces of cautionary advice that they might give to a younger student. It is what the study must do if it is to produce results that can be handled statistically.

It is no wonder that some of the subjects balked at performing as they were asked. However, after making introductory qualifications (many of which are reported above), most of the subjects who composed the sample group were willing to cooperate wholeheartedly in attempting to answer the problem posed within the limitations established. On the other hand, several continued to argue throughout the interview. Outstanding among these was Mr. Holcomb of Ohio State, who said, in answer to a question about the arbitrary method of the experiment:

> HOLCOMB: If you had just changed the wording a little bit, I could have picked out the same reasons for not going into education, or for not going into something else. It's simply I just don't differentiate science as a special thing.

A few moments later, he returned to this tack and said:

> HOLCOMB: I don't like the emphasis on the scientific method. Hypothesis, you know, and conclusions. All of this, in actual scientific research, there isn't any ... there just isn't processed any more than anything else. (*sic*)

And after a question which attempted to clarify the intention of the experiment, he still replied: "There's no more difference between science and education than there is between education and English, or education and ... " The whole interview with Holcomb continued in this vein. He was unwilling to come to terms with the experiment and accept its arbitrary nature.

Fortunately, Mr. Holcomb was a rarity. Most of the rest of the subjects worked diligently at satisfying the requirements of the experiment and after their qualifying remarks, treated the discussion of the card-sort "as if" they had planned to be scientists in the naive sense of the term. It is best, though, that we keep in mind the variety and contrary character of the decision pattern the subjects actually represent, and recognize that, in truth, many of the statements reported were made in a somewhat artificial context.

Chapter IV

Statistical Analysis of the Data

In this chapter, we will analyze the numerical data collected at the time the subjects were tested through the use of the Q-sort technique.

Of the 121 respondents, 119 sorted the cards and two did not. Both the latter were students at Stanford University, and each did complete his interview. One subject, a student at Brooklyn College, completed the card-sort, but was unable to finish the interview. All the remaining 118 subjects completed both the sort and the interview.

One of the two students who refused to sort the cards was Robert Locke, a member of the experimental sub-group, who had changed his major from mathematics to music. Locke described himself as being "annoyed" by the statements included in the card sort, and then went on to say:

> LOCKE: ... that a lot of these questions were, as I was very antagonistic toward ... they didn't enter at all into my choice for myself because I didn't think they applied, so I'd be annoyed by them and, at the same time, it wouldn't be part of my reason.

At times, other subjects who did complete the sorting procedure, made similar comments, albeit parenthetically. During the course of their interviews, they contended that they had been made anxious by what they considered to be the constraint imposed upon them by the forced-choice card-sort.

The 119 subjects who completed the card-sort constitute a statistical group, and it is the shape and structure of their response which we shall examine for the remainder of this chapter. However, first a caution: our sample group is not the produce of a process of random selection. Whereas it has, we think, something important to say about the choice of an academic major by students who could have successfully completed a major in one of the natural sciences, we cannot logically maintain that it accurately represents the whole population of students. This is because each and every student who might conceivably have been a candidate for the study has not had an equal opportunity to participate.

Nevertheless, the several members of the sample group have, through their card choices and through the interviews prompted by these choices, told a relatively consistent story about their experiences with a science or engineering major. To establish the quantitative dimensions of this story, we will begin first with a report on the characteristics of the distributions of the 32 cards as placed by the sample group as a whole, and second, with one on the distributions as recorded for the major sub-groups of the sample. This is taken up in Section A, entitled Quantitative Dimensions of the Sample Group, below.

There are two pairs of sets of such sub-groups to be considered, along with the sample group as a whole, and they are exhaustive. The first paired set is that composed of the experimental and control sub-groups. This set is exhaustive in the sense that a respondent must either be a member of one or the other of the sub-sets comprising the set (or sample group). This also holds for the second pair of sub-groups, which is composed of those who majored in engineering and those who majored in science. A respondent must, at some time in his academic career, have been a major in either one or the other of these two general areas of concentration. The third of the three possible sets of exhaustive sub-groups -- the college which the subjects attend -- was not considered statistically after a preliminary examination indicated that there were no important differences in card placement recorded.

The prefatory analysis of the data in Section A is the direct product of certain features built into the Q-sort test. At the beginning of the test, the subject is given 32 cards with cautionary statements printed on them and is asked to place each of these cards in one of seven piles, numbered ordinally from 1 to 7. By definition, card placements in piles 1, 2, and 3 indicate, with decreasing intensity, that the subject is disposed to agree that the statement on the card is a good piece of advice to give to a younger student who is serious about becoming a scientist. Card placements in piles 5, 6, and 7 indicate, with increasing intensity, that the subject feels that the statement on the card would be a misleading or ridiculous piece of advice to give to the student in question. A place in pile #4 indicates that the subject is relatively indifferent to the statement on the card.

Statistically, we treat the responses to the test as if each card placement had been made along a dimension that is scalar and is composed of discrete cells numbered from 1 to 7. Number 1 is considered to be the extreme positive statement, and number 7 the extreme negative. Furthermore, in making interpersonal statistical comparisons, we treat the numbered responses as if they were cardinal, which means that everyone has the same value loading in mind when making his placements. Intuitively, however, there is some objection to this procedure, and it is for this reason that all our quantitative comparisons should be considered with great caution. By definition, the seven cells are not scalar. Each subject is asked to place cards in terms of a "good piece of advice" at one end, the positive or number 1 end, and in terms of what he considers "misleading" or "ridiculous" at the other or negative (number 7) end of the dimension. Cards remain in cell #4 because they don't mean anything to him, not because they are half way between a clearly defined guidepost at #1 and another at #7. In fact, on reading the interviews, one often has the rather peculiar feeling that the extremes were sometimes located closer together in the subject's mind than they were to the centrally placed cards. About them, he had feeling; about the others he didn't care. An example of the sort of confusion that may exist internally can be found in the discussion of the Conventional cluster in Chapter VI, below. One must also keep in mind, throughout, that the seven cells are not located cardinally, but ordinally, depending entirely on the subject's decision as to the attention he may give to the test, and what weights and distances he assigns to the seven cells.

Furthermore, the fact that Q-sort is a forced-choice procedure adds a probability dimension to the response. The subject may place a fixed number only of his 32 cards in each of the piles. Ten of his 32 cards must be placed in pile 4, seven in each of piles 3 and 5, three in each of piles 2 and 6, and one in each of piles 1 and 7. Thus, for any given card, were the placement procedure a matter of chance alone, the probability would be 10/32 that the subject would place the card in pile #4. Similarly, the probabilities for placement in each of the other six piles, were it a matter of chance, can be readily computed from the information just given.

For any group of subjects taken collectively, the mean placement of the group for a specific card can range, at the extreme, from 1 to 7. However, the mean of the group's distribution for any specific card is likely to approximate 4.0. This, again, is due to the forced-choice feature in the construction of the examination. For example, the chances that a person will place any single card in either piles #1, #2, or #3 are 11/32 or approximately 1 in 3. The chances that a mean for a group of two persons for any single card will be 3.0 or less are 215/1024, or approximately 1 in 5. For a three-person group, the chances that the mean will be 3.0 or less fall again and are now 4487/32768 or approximately 1 in 8. And the chances that such a mean will occur have already fallen to the point where, were the group constructed for the purpose of testing a hypothesis, they would be significant at the 10% level when we reach four persons for the group. As the group increases in size, the chances of an extreme mean continue to decline. The same probabilities hold, also, for means that are five or greater than five.

Our sample group includes 119 subjects. With a group of this size we can expect the mean for the distribution for a single card to cling close to

4.0 unless the statement on the card inspires a considerable amount of agreement at one or the other of the extremes. At the same time, however, a mean of 4.0 is decidedly ambiguous. For such a mean can result either from most of the subjects placing a card in pile #4 and thereby registering their relative indifference to the statement in question, or from compensating differences among the several subjects, and thereby be the result, not of indifference, but of strong feelings about the statements For example, card #23, with a mean for the distribution of exactly 4.0, is bi-modal in shape, being:

2 - 24 - 26 - 18 - 28 - 18 - 3 for the seven piles

The piles are numbered from the left from 1 to 7. And card #28 has three peaks in its distribution and, with the tips of its wings and its body held high, looks something like a bird in flight, being:

12 - 10 - 22 - 43 - 20 - 4 - 8 for the seven piles

The mean for card #28 is 3.8 and is not unusual. Yet, these two cards finally turn out to be among the most interesting for the complete analysis. Of course, the standard deviations for both are well above the average.

The technique of analysis utilized in Section A singles out cards distributed atypically by the subjects. However, the mean alone is inadequate for our purposes, and is not the only method used in the body of the section. To further augment the analytical treatment we have, along with the means of distributions, also computed the standard deviations. In addition, we have recorded the results of several tests of significance as well. This has been done both for the sample group as a whole and for the major sub-groups. Nevertheless, this treatment has its limitations, and for that reason can only be considered prefatory. Through it, cards rather than subjects are singled out for special analysis.

Since our interview material consists of statements about a limited number of cards and about other ancillary matters of interest to them by subjects, efficient use of these interviews cannot be made unless we employ a method of analysis that singles out subjects rather than cards. The analysis in its prefatory form tells us nothing about patterns of card placement by subjects. For instance, we do not know from the above example whether a subject who placed card #23 positively would be more or less likely to do the same for card #28. And it is important to know this. Our subjects are presumably intelligent persons integrated within themselves, and, although the statements exist as 32 discrete possibilities for advising a younger person, it would be unreasonable not to expect them to try to tie their separate decisions together into a cohesive whole and create a characteristic profile. Here again, a treatment that would direct the investigators to the subjects themselves rather than to the cards would be helpful. And finally, the prefatory treatment has nothing to say about possibilities for the existence of sub-groups, and possibly contending sub-groups within the sample group. A priori, we have defined two sets of exhaustive sub-groups within the sample group, but at this time, we cannot tell whether there might not be others, and others that are not exhaustive, nor do we know whether the two sets as defined by the procedure itself are the most significant examples of non-homogeneity exhibited in the data.

To get around the limitations of the prefatory analysis, a second level of treatment, more synthetic in principle, is considered in Section B. This is the section entitled Cluster Construction and Analysis. Therein, distinctions between persons and groups of persons are developed from the Q-sort data. Essentially, the method involved the use in several ways of a conventional measure of distance between subjects. This is the D^2 distance measure and is computed by calculating the sum of the squared differences between each pair of profile elements. The profile elements are the 32 cards. For any element, say for card #1, each of two subjects must have placed that card in one of the seven piles. The theoretical distance possible for that card between subject would result when the card was placed in the two extreme piles, or six piles apart. For this placement, the D^2 would be 36. The minimum distance possible is zero. For any two subjects, the D^2's for the 32 profile elements can be summed after all the placement distances between each pair of elements has been computed. This product, the sigma-D^2's for the 32 profile elements, is retained throughout as the established measure of distance between subjects. At the ideal maximum, it can be as high as 224, for the forced-choice feature of the test allows for only two D^2's between pairs of 36, and at the ideal minimum, it can be 0. For the experiment, however, the highest product recorded for any pair of subjects was 186, and the lowest was 26.

This procedure, then, leads us to an important assumption because this product is taken to serve as an index of subjective agreement or disagreement by the subjects. For the purposes of our study, it is accepted, tentatively, that a pair of subjects whose sigma-D^2 score is less than that for another pair of subjects are more likely than not to be in agreement as to what the disadvantages of a science career are than are the other pair with the higher sigma-D^2. For instance, that the pair who recorded the sigma-D^2 product of 26 were likely to be in agreement and that the pair with the 186 were likely to be in disagreement. While no entirely satisfactory test of this assumption is possible, the interviews with each subject give reasons as to why they chose the cards they placed at the extremes during the test, and can be used to corroborate judgments made from the card placements alone. And this, of course, has been done in detail, and is the basis for the extensive analysis of clusters in Chapter VI.

Our next step, after having computed the sigma-D^2 distance between every possible pair of subjects, was to use these distance scores to locate group tendencies within the sample. When several individuals are found to have placed their cards in similar patterns so that they have low distance scores relative to each other, we assume that they have taken a like position relative to the question being studied. We have called such statistically inferred groups clusters. The actual procedure, including cut-off scores for constructing clusters from the raw data is described in detail in Section B. The method described there has yielded us nine such clusters of from five to thirteen subjects, including 64 of the 121 subjects altogether. While many of the remaining 57 may have placed their cards so as to be located topologically close to one or several of the actual clusters, they do not qualify and have been excluded from the detailed analysis as being categorically impure types.

The clusters having been located and their membership fixed, our next step was to compute the mean card placement for each cluster and the standard deviation of that mean. By this method, we are able to identify the important progenitive cards in each cluster. Thus, for card #1, one cluster with twelve members has a mean placement for this card of 6.1, and at the other extreme, another cluster with eleven members has a mean placement for this card of 3.8. This suggests that the members of all groups are negatively disposed toward this card. For the aforementioned card #28, there is one cluster with eight members which has given the card a mean placement of 2.5, and another with five members which has given the card a mean placement of 6.0. If the statistics reflect accurately the actual subjective feelings of the memberships of the two clusters, it seems that there is considerable disagreement between the two groups as to the significance of the statement on card #28 as advice suitable for a younger person considering a science career. And, we should remember that for the sample group as a whole, the mean placement for card #28 was 3.8.

By means of our clusters, we are now able systematically to utilize the interview data. It is possible for the reader to make a cross-check of the subjects recorded within a single cluster, both as to what kind of persons they are and as to how their answers on similar cards compare. For instance, for the five member cluster that recorded card #28 with a mean of 6.0, three of the members placed the card as their 7th or most negative choice. Thus, it is a card they would have discussed in their interview. For the eight member cluster that placed the card with a mean of 2.5, two place it first and one placed it in the second pile. Four of the remaining five members placed #28 in their third pile of cards. This indicates that they still were positively disposed toward the card, but had other cards toward which they were more positively disposed. However, while they had this positive disposition in minor degree, they would not have specifically discussed the card in the interview.

This underscores a limitation in trying to analyze the data in terms of progenitive cards alone, using a simplified form of content analysis such as was suggested by the discussion in the last paragraph. The interviews when centered mechanically on significant cards, do not always yield a sufficient quantity of relevant data. For certain of the cards that are important in generating a cluster, only a meager amount of direction discussion material exists. That is true for the eight member cluster's response on card #28, as reported above. Number 28 is important to the members of the cluster as their second most positive choice, but it is important, not only as a direct response, but also as a manifestation of the total response of the persons questioned. In addition, there are times when the subjects wander away from a strict consideration of the card in question. There are many examples of this in the text in Chapter VI.* It is clear there that many of the subjects used the cards as points of departure, and, indeed, the interviewer encouraged such a use.

Sometimes, the subjects stated that their answers did not refer to the whole statement being considered, but only to a specific part of it. For instance, in discussing the basis on which he decided to pick his cards, Mr. Gulder of Brooklyn College, says:

> GULDER: I would say that the cards themselves that I picked out those that were closest to me ... but ... you know, closest to the opinions that I had ... but some of them in the first paragraph sort of put in what I like and in the second took it away.

And others chose to treat the several cards as a unit. As an example of this, Mr. Meeks also of Brooklyn College, had this to say:

> MEEKS: (in reference to card #8 as a negative choice) I think this card #8 fits in with some of the others in this group ... card #22 and somewhat in line with card #30. ... I prefer to answer them as a group.

For all these reasons a strictly mechanical application of the numbered responses seemed to us to be ill-advised in that it would be likely to distort the findings. As we indicated earlier, we consider the subjects to be integrated within themselves. Therefore, in our discussion of the response to the card-sort, we plan to use the recorded placements in three ways. First, as indicators of response characteristics; second as guides to the identification of the person making the response as an entity; and third, to help in the construction of a representative, albeit limited, personality for each cluster.

In working with the data, we have found that this is possible, The pattern of choices, and the things the subjects chose to say or avoid saying concerning this pattern of choices do merge together into a coherent whole. However, one must be very cautious in combining quantitative findings with subjective inferences. Despite the dangers involved, we have derived our analysis in Chapter VI both from the subjects' card choices and from our impressions of their interviews. We have done this because we feel that both factors are important, that the data point to the use of both, that they complement and support each other, and that a strictly mechanical method of reporting our findings would, despite its seeming correctness, be misleading.

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* For example, see the discussion of Messrs. Eero and Harcourt on card #17.

With means and standard distributions for each of the clusters computed, and with some understanding of the significance of this quantitative response imparted through a consideration of the interview material, it becomes possible to compare the clusters with the sample group as a whole, the sub-group controls versus the sub-group experimentals, and with each of the other clusters. This has been done quantitatively in Section B, below, and more impressionistically, in Chapter VI. With the completion of this step in the analysis we are able to ascertain what point or points of view, as inferred from the clusters, are central to the positions taken by the young science and ex-science students as a collectivity. We are also able to determine which of the clusters represents highly characteristic points of view.

There remains one further application for our quantitative data. That is, to test the hypotheses introduced in Chapter I. This has been done in the following manner. Professor Friedenberg was responsible originally for having written the original statements for the 32 cards. At that time, he attempted to provide a list of reasons for leaving a major in the natural sciences which would be comprehensive and at the same time touch on matters which had seemed important in previous research.* On the whole, the cards have been successful. Although each subject was asked to suggest reasons other than the 32 listed, most of them failed to recommend any important addition to the list.**

After having completed the interviews, but prior to the time when he gave detailed attention to the analysis of the data, Professor Friedenberg made three complete sorts of the cards, using as his guide in each case his understanding of what the three hypotheses entailed. For each hypothesis, he sorted the cards as if he were a student who was representative of that hypothesis and was asked to sort the cards. Professor Friedenberg's three sorts are recorded in Section C, Conjectural Card Sorts and the Comparison of these Sorts with the Findings, which is the final section of this chapter.

In addition, in Section C, we have compared the Friedenberg's Conjectural sort in each case with the mean responses for the nine clusters, the experimental sub-group, the control sub-group, and the total sample group through the use of D^2 distances. However, we have not attempted to establish significance levels for these data, for, as will be obvious in examining the distance results themselves, the distance recorded is often the result of a few extreme cards and not necessarily of the total profile. These data, also, as recorded for each card's mean placement, are reported in Section C. The extent to which these data bear upon the hypotheses will be discussed extensively in Chapter VII, the final chapter of the monograph, after the clusters themselves and their significance has been considered in detail.

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* An example of this is card #5, which is an attempt to summarize the position taken by Margaret Mead. Mead, Margaret, Metraux, Rhoda, "Image of the Scientist Among High School Students," Science, 126, August 30, 1957.

** The one important addition which might have been made refers to the place of women in the science curriculum. It has already been discussed in Chapter III.

Section A
Quantitative Dimensions of the Sample Group

(1) Observed Results as Recorded for the Total Sample Group

In completing the Q-sort test in this experiment, each of 119 respondents distributed 32 cards, numbered 1 through 32, among seven consecutively numbered piles. Their was a forced-choice distribution. The instructions given the respondent required that he place one of his 32 cards in pile #1, three in pile #2, seven in pile #3, ten in pile #4, seven in pile #5, three in pile #6, and the remaining card in pile #7. A descrption of the complete procedure for card placement can be found in Chapter II.

As a consequence of the forced-choice feature in the test, it becomes possible to compute certain probable results for a distribution of the cards by a group of respondents, were the distribution the product of chance alone. For a group of infinite size, the expected mean of the distribution over the seven piles for any one of the 32 numbered cards would be 4. The ideal standard deviation from this mean would be 1.3229, and the standard error of the mean, .12178. It is also possible to compute a theoretical frequency distribution for the seven piles for each of the 32 cards. For 119 subjects, this distribution was found to be:

Pile #	1	2	3	4	5	6	7	N
	3.719	11.156	26.031	37.188	26.031	11.156	3.719	119

This distribution can be used both for direct comparison with the actual results as recorded on Table 6 and for testing these results through the use of a standard Chi-square test.

In addition to the results of the actual distribution of the 32 cards and the mean and standard deviations for each of these distributions, results for two standard tests of significance are recorded on the table below. For an infinite population, T=2.576. When the mean for the distribution as actually recorded falls outside the range 3.68 to 4.32, the 1% level of significance has been exceeded, or, more concretely, were the distribution recorded the product of chance alone, chances are less than one in one hundred that a mean of less than 3.68 or more than 4.32 would have been recorded. Such means as do exceed the 1% level of significance in the table below have been identified with an asterisk (*).

It is also interesting to note that were the samples the product of chance alone, the probability is only one in three that, of 32 successive samples of 119 subjects, the mean of one (and only one) of them would exceed 4.32. The same holds for the probability that a mean would be less than 3.68. Actually, seven of the means recorded below exceed 4.32 and seven are less than 3.68.

The 32 card placement distributions were also tested by means of a Chi-square test to ascertain whether the observed frequencies depart significantly from the expected frequencies as reported above. For seven cells into which a card could have been placed, with six degrees of freedom, the Chi-square value at the 1% level of signifiance is 16.812. Nineteen of the computed Chi-squares exceed this value. The Chi-square values as computed for all 32 cards are also recorded on the table below.

Table 6

Card	Number of Cards Falling in each Pile									Chi-Square
Number	1	2	3	4	5	6	7	Mean	Sd.	Value
1	1	1	13	30	29	32	13	5.0*	1.27	81.623
2	1	10	26	38	31	12	1	4.1	1.17	5.126
3	1	10	20	37	37	14		4.2	1.15	12.572
4		2	12	39	43	22	1	4.6*	.98	42.474
5	1	5	26	30	29	13	15	4.5*	1.42	41.641
6	4	18	53	33	11			3.2*	.94	56.186
7	2	8	29	39	28	12	1	4.0	1.18	4.315
8	2	10	12	18	33	30	14	4.8*	1.51	80.496
9	2	24	50	32	10	1		3.2*	.95	61.244
10		11	37	50	18	3		3.7	.92	24.917
11	4	17	33	40	17	6	2	3.6*	1.24	11.471
12	3	6	28	47	31	3	1	3.9	1.05	14.159
13	2	5	34	34	27	12	5	4.1	1.26	7.444
14		3	16	59	28	11	2	4.3	.95	27.287
15	1		5	56	43	14		4.5*	.82	55.158
16	2	12	27	43	25	8	2	3.9	1.19	3.531
17	23	33	28	16	14	2	3	2.9*	1.48	168.177
18	13	39	35	18	12	2		2.9*	1.21	124.442
19	1	7	28	27	43	13		4.2	1.14	21.561
20	3	10	25	47	20	6	8	4.0	1.32	11.598
21	1	10	19	20	28	29	12	4.7*	1.50	59.081
22	2	6	19	36	41	14	1	4.3	1.15	16.434
23	2	24	26	18	28	18	3	4.0	1.50	29.967
24	4	5	31	36	30	12	1	4.0	1.21	7.061
25	4	14	27	40	22	9	3	3.9	1.30	2.175
26	4	13	35	48	13	4	2	3.6*	1.13	18.467
27	19	15	22	38	12	10	3	3.4*	1.57	88.446
28	12	10	22	43	20	4	8	3.8	1.54	31.010
29	2	10	30	41	22	12	2	4.0	1.22	3.392
30		3	16	32	32	22	14	4.8*	1.29	54.605
31	3	9	22	44	34	5	2	4.0	1.15	9.058
32		6	26	59	23	4	1	4.0	.91	25.827

(2) Observed Results and Comparison Analysis for the Major Sub-Groups - Experimental and Control

Of the 119 subjects who sorted the cards, 73 had begun their college careers with the intention of being majors in some field of natural science or engineering and have since left this major (herein called Experimentals) and 46 have remained as majors (herein called Controls).

Below, in tabular form, are the card-sorts as distributed over the seven cells for each of the 32 cards. The Experimental group distribution is recorded first and that of the Controls second. In addition, the mean and standard deviation for each group has been recorded, and finally, the T score measuring the difference between the means for each of the two group distributions, Experimental and Control, has also been computed and is recorded below.

By means of the T-test, the hypothesis: that for each of 32 separate distributions by 73 Experimentals and 46 Controls, the means of the distributions consequent on the sorting of cards by experimentals and the means of the distributions consequent on the sorting of cards by controls do not differ significantly from those which would be expected were the two distributions the product of individual sorters who were members of the same general population, is tested.

A T score exceeding 2.576 indicates a difference in means greater than that which would be expected at the 1% level of significance, and one exceeding 1.960, one that would be expected at the 5% level of significance. For 32 independent distributions, the probability is approximately 1 in 3 that one of the tested sets of distributions will exceed the 1% level of significance, and approximately 1.6 to 32 for the 5% level of significance.

$$T = \frac{D-0}{\sigma_D}$$

where: $D = M_x - M_c$

and: $\sigma_D = \sqrt{\sigma^2_{M_x} + \sigma^2_{M_c}}$

x = Experimentals and c = Controls

$N_x = 73$ and $N_c = 46$

Table 7

Comparison Analysis - Experimental Subjects and Control Subjects

Card	Number of Cards Falling in Each Pile											
Number	1	2	3	4	5	6	7	Mean	Sd	T-Test	1%	5%
1-Exp		1	9	14	22	18	9	5.0	1.25)			
1-Con	1		4	16	7	14	4	4.9	1.30)	+ .410		
2-Exp		4	13	21	23	11	1	4.4	1.14)			
2-Con	1	6	13	17	8	1		3.6	1.05)	+3.883	*	*
3-Exp		4	7	26	25	11		4.4	1.03)			
3-Con	1	6	13	11	12	3		3.8	1.22)	+2.740	*	*
4-Exp		1	5	20	30	16	1	4.8	.95)			
4-Con		1	7	19	13	6		4.3	.96)	+2.747	*	*
5-Exp		2	12	17	21	9	12	4.8	1.37)			
5-Con	1	3	14	13	8	4	3	4.0	1.37)	+3.077	*	*
6-Exp	1	10	29	23	10			3.4	.94)			
6-Con	3	8	24	10	1			3.0	.86)	+2.367		*
7-Exp	2	4	13	24	20	9	1	4.2	1.23)			
7-Con		4	16	15	8	3		3.8	1.04)	+1.879		
8-Exp	1	8	11	13	17	14	9	4.6	1.58)			
8-Con	1	2	1	5	16	16	5	5.2	1.30)	-2.230		*
9-Exp	2	9	34	20	7	1		3.3	.95)			
9-Con		15	16	12	3			3.1	.92)	+1.130		
10-Exp		6	21	30	13	3		3.8	.96)			
10-Con		5	16	30	5			3.5	.83)	+1.786		
11-Exp	1	10	19	26	14	2	1	3.7	1.13)			
11-Con	3	7	14	14	3	4	1	3.5	1.36)	+ .823		
12-Exp	3	4	17	30	17	1		3.8	1.10)			
12-Con		2	11	17	14	2		4.1	.94)	-1.571		
13-Exp	1	4	19	22	18	6	3	4.1	1.25)			
13-Con	1	1	15	12	9	6	2	4.2	1.30)	- .410		
14-Exp		3	8	38	16	7	1	4.3	.97)			
14-Con			8	21	12	4	1	4.3	.93)	0.0		
15-Exp			2	33	30	8		4.6	.72)			
15-Con	1		3	23	13	6		4.4	.94)	+1.220		
16-Exp	1	5	13	29	16	7	2	4.1	1.19)			
16-Con	1	7	14	14	9	1		3.6	1.10)	+2.315		*

Table 7 (continued)

Comparison Analysis - Experimental Subjects and Control Subjects

Card Number	Number of Cards Falling in Each Pile 1	2	3	4	5	6	7	Mean	Sd.	T-Test	1%	5%
17-Exp	11	21	22	10	8	1		2.8	1.25)			
17-Con	12	12	6	6	6	1	3	2.9	1.78)	-0.329		
18-Exp	8	22	21	12	8	2		2.9	1.29)			
18-Con	5	17	14	6	4			2.7	1.10)	+0.893		
19-Exp		6	19	15	24	9		4.1	1.18)			
19-Con	1	1	9	12	19	4		4.3	1.08)	-0.939		
20-Exp	2	2	17	29	15	5	3	4.1	1.20)			
20-Con	1	8	8	18	5	1	5	3.8	1.49)	+1.136		
21-Exp	1	6	18	11	14	17	6	4.5	1.54)			
21-Con		4	1	9	14	12	6	5.0	1.31)	-1.873		
22-Exp	1	5	12	22	24	8	1	4.2	1.18)			
22-Con	1	1	7	14	17	6		4.4	1.05)	-0.957		
23-Exp	2	21	15	11	15	9		3.6	1.23)			
23-Con		3	11	7	13	9	3	4.5	1.38)	-3.358	*	*
24-Exp	2	4	23	23	12	8	1	3.9	1.22)			
24-Con	2	1	8	13	18	4		4.2	1.16)	-1.327		
25-Exp	4	12	18	24	11	2	2	3.5	1.32)			
25-Con		2	9	16	11	7	1	4.3	1.16)	-3.433	*	*
26-Exp	2	11	25	30	4		1	3.4	.99)			
26-Con	2	2	10	18	9	4	1	4.0	1.23)	-2.752	*	*
27-Exp	15	12	13	21	4	7	1	3.2	1.60)			
27-Con	4	3	9	17	8	3	2	3.8	1.43)	-2.106		*
28-Exp	9	4	14	26	12	3	5	3.8	1.56)			
28-Con	3	6	8	17	8	1	3	3.8	1.44)	0.0		
29-Exp	1	5	18	25	14	9	1	4.1	1.21)			
29-Con	1	5	12	16	8	3	1	3.8	1.22)	+1.299		
30-Exp		3	10	21	16	13	10	4.8	1.37)			
30-Con			6	11	16	9	4	4.9	1.14)	-0.427		
31-Exp	3	5	12	28	21	3	1	4.0	1.13)			
31-Con		4	10	16	13	2	1	4.0	1.10)	0.0		
32-Exp		4	21	35	11	1	1	3.8	.90)			
32-Con		2	5	24	12	3		4.2	.87)	-2.381		*

(3) Observed Results and Comparison Analysis for the Major Sub-Groups - Science Majors and Engineers

Of the 119 subjects who sorted the cards, 63 had begun their college careers with the intention of being majors in some field of natural science and 56 began with the intention of majoring in engineering.

Below, in tabular form, are the card-sorts as distributed over the seven cells for each of the 32 cards. The science major group distribution is recorded first and that of the engineers second. In addition, the mean and standard deviation for each group for each card have been recorded, and finally, the T-score measuring the difference between the means for each of the two group distributions, science and engineering, has also been computed and is recorded below.

By the means of the T test, the hypothesis: that for each of 32 separate distributions by 63 science majors and 56 engineering majors, the means of the distributions consequent on the sorting of cards by science majors and the means of the distributions consequent on the sorting of cards by engineering majors do not differ significantly from those which would be expected were the two distributions the product of individual sorters who were members of the same general population, is tested.

A T-score exceeding 2.576 indicates a difference in means greater than that which would be expected at the 1% level of significance, and one exceeding 1.960 one that would be expected at the 5% level of significance. For 32 independent distributions, the probability is approximately 1 in 3 that one of the tested sets of distributions will exceed the 1% level of significance, and approximately 1.6 to 32 for the 5% level of significance.

The T-score of each card has been computed accorded to the formula:

$$T = \frac{D-0}{\sigma_D}$$

where: $D = M_E - M_S$

and: $\sigma_D = \sqrt{\sigma^2_{M_E} + \sigma^2_{M_S}}$

E= Engineers and S= Science majors
$N_E = 56$ and $N_S = 63$

Table 5

Comparison Analysis - Science Subjects and Engineering Subjects

Card Number	Number of Cards Falling in Each Pile											
	1	2	3	4	5	6	7	Mean	Sd.	T-Test	1%	5%
1-Sci	1		6	10	11	18	8	5.0	1.32)			
1-Eng		1	7	11	18	14	5	4.9	1.21)	+0.426		
2-Sci		3	16	25	12	5	1	4.1	1.05)			
2-Eng	1	7	10	13	18	7		3.6	1.30)	+3.030	*	*
3-Sci		8	10	20	20	5		4.1	1.14)			
3-Eng	1	2	10	17	17	9		4.3	1.13)	-0.842		
4-Sci		1	5	18	27	12		4.7	.92)			
4-Eng		1	7	21	18	10	1	4.5	1.03)	+1.099		
5-Sci	1	1	15	11	12	5	8	4.4	1.29)			
5-Eng		4	11	9	17	8	7	4.6	1.45)	-0.700		
6-Sci	1	9	31	10	3			3.2	.81)			
6-Eng	3	9	23	14	8			3.3	1.08)	-0.588		
7-Sci		7	18	20	18	4		3.9	1.09)			
7-Eng	2	1	13	19	12	8	1	4.3	1.24)	-1.882		
8-Sci		1	6	12	18	16	7	5.1	1.21)			
8-Eng	2	9	6	6	15	11	7	4.5	1.72)	+2.143		*
9-Sci	1	13	28	10	2			3.1	.83)			
9-Eng	1	11	23	13	8	1		3.3	1.08)	-1.126		
10-Sci		4	21	25	10	3		3.8	.85)			
10-Eng		7	16	25	8			3.6	.86)	+1.170		
11-Sci	4	10	17	18	9	4	1	3.5	1.34)			
11-Eng		7	16	22	8	3	1	3.7	1.06)	-0.883		
12-Sci	1	3	13	27	17	1	1	4.0	1.01)			
12-Eng	2	3	15	20	14	2		3.8	1.08)	+1.026		
13-Sci	2	4	18	15	16	6	2	4.0	1.32)			
13-Eng		1	16	19	11	6	3	4.2	1.10)	-0.858		
14-Sci		2	12	20	18	3	1	4.1	.91)			
14-Eng		1	4	29	12	9	1	4.5	.97)	-2.312		*
15-Sci	1		1	30	22	9		4.6	.87)			
15-Eng			4	26	21	5		4.5	.70)	+0.618		
16-Sci	1	8	17	22	11	3	1	3.7	1.15)			
16-Eng	1	4	10	21	14	5	1	4.1	1.18)	-1.860		

Table 8 (continued)

Comparison Analysis - Science Subjects and Engineering Subjects

Card Number	Number of Cards Falling in Each Pile 1	2	3	4	5	6	7	Mean	Sd.	T-Test	1%	5%
17-Sci	13	19	14	6	7	1	3	2.8	1.59)			
17-Eng	10	14	14	10	7	1		2.9	1.34)	-0.368		
18-Sci	6	20	18	10	9			2.9	1.19)			
18-Eng	7	19	17	8	3	2		2.8	1.21)	+0.446		
19-Sci	1	4	14	15	22	7		4.2	1.18)			
19-Eng		3	14	12	21	6		4.2	1.11)	0.0		
20-Sci	2	8	13	23	10	2	5	3.9	1.41)			
20-Eng	1	2	12	24	10	4	3	4.1	1.20)	-0.830		
21-Sci		2	11	11	13	20	6	4.9	1.26)			
21-Eng	1	8	8	9	15	9	6	4.4	1.60)	+1.605		
22-Sci	2	4	9	17	24	6	1	4.3	1.24)			
22-Eng		2	10	19	17	8		4.3	1.04)	0.0		
23-Sci	1	10	14	6	22	8	2	4.1	1.46)			
23-Eng	1	14	12	12	6	10	1	3.8	1.51)	+1.087		
24-Sci	4	4	17	15	15	8		3.9	1.36)			
24-Eng		1	14	21	15	4	1	4.2	1.00)	-1.370		
25-Sci	1	7	13	19	14	7	2	4.1	1.32)			
25-Eng	3	7	14	21	8	2	1	3.6	1.24)	+2.110		*
26-Sci	2	6	20	23	9	3		3.7	1.08)			
26-Eng	3	7	13	25	4	1	3	3.6	1.18)	+0.481		
27-Sci	10	8	9	23	6	6	1	3.5	1.55)			
27-Eng	9	7	13	15	6	4	2	3.4	1.58)	+0.342		
28-Sci	5	5	10	25	8	4	6	4.0	1.50)			
28-Eng	7	5	12	18	12		2	3.6	1.43)	+1.471		
29-Sci	1	6	14	25	11	5	1	3.9	1.18)			
29-Eng	1	4	16	16	11	7	1	4.0	1.28)	-0.439		
30-Sci		2	4	18	19	14	6	4.9	1.19)			
30-Eng		1	12	14	13	8	8	4.7	1.38)	+0.830		
31-Sci	2	8	13	20	18	1	1	3.6	1.23)			
31-Eng	1	1	9	24	16	4	1	4.2	1.04)	-2.057	*	*
32-Sci		3	14	33	11	2		3.9	.84)			
32-Eng		3	12	26	12	2	1	4.0	.97)	-0.595		

Section B

Cluster Construction and Analysis

To identify subjects who had similar card-choice patterns*, we began by calculating the sum of the squares of the thirty-two differences in pile placement for each of all possible pairs of individuals. Since there were 119 subjects who paired with 118 others, this produced 14,042 comparisons stated in terms of a sigma-D^2. At the extremes, these sigma-D^2 pairings ranged from a low of 26 to a high of 186. Seventy, an arbitrary cut-off point was then selected and all sigma-D^2 that fell above this number were eliminated from the next stage of the program. Such pairings are called "coincidents" in the discussion below. In addition, all individuals for whom less than three sigma-D^2 pairings of 70 or less with other members of the sample group were recorded were also removed from consideration. By these means, 22 individuals were pruned off the study sample and the number of those to be considered for clustering was reduced to 97. The cut-off point was set at 70 so as to admit as many subjects into the second stage of the program as the available computing equipment could handle efficiently.

The remaining 97 subjects generated 839 coincidents or pairings with a sigma-D^2 of less than 70. This then meant that we had reduced the number of pairings taken into account from 14,042 to 839 by the pruning process described above. Next, through the use of the computer, we listed the 97 groups consisting of three or more subjects produced by the 97 individuals, and along with them calculated statistical indices of the closeness of cohesion for the several groups and of the extent to which each individual included in the group contributed to its formation. At this point, each group engendered by one of the 97 subjects was composed of three or more members, with the largest group being one of 37 members.

Ninety-seven clusters were clearly too many. To reduce the number to a more manageable size, we plotted a matrix of all the individuals for whom these pregenerated groups had been constructed, using the listing in groups as a guide in ordering the individuals on the matrix. By means of this matrix, we were able to recognize the existence of clustering tendencies among the 97 individuals. Such clustering appeared when there were inter-coincidents and there were many examples of these inter-coincidents observable. An inter-coincident occurs when two individuals, each of whom has a coincident with a third person, have a sigma-D^2 distance of less than 70 with each other. It was also possible to remove some 31 of the subjects at this time. These were individuals who, on observation, contributed little to the crudely defined clusters that existed on the first matrix. Using the remaining 66 subjects, we then constructed a second matrix. To give the observer an opportunity to ascertain whether galaxies of a different structure would appear, the order of the individuals was rearranged for this second matrix.

By use of these two matrices and the list of 97 progenerated groups, the investigators were enabled to construct the unique set of clusters employed for analysis in this report. As we were not so much interested at this point in central tendencies within the group as we were in structural manifestations of non-homogeneity, we looked for cases where groups of individuals had intercoincidents with a few subjects as well as cases where groups of individuals had intercoincidents with many. For example, it is possible that 20 or 30 of the subjects might have had sigma-D^2 pairings with each other of less than 70 and with almost no one else. It is also possible that this could have been the case for only five subjects. Should this have happened to be true, we felt, both intercoincidental collectivities deserved investigation. Therefore, we established criteria for admission of an individual to a cluster, that would lead to both possibilities. These criteria are as follows: for any individual to be admitted to a cluster, he must, if he has 10 or fewer coincidents with all members of the group of 97, have coincidents with at least one-half of the other members of the cluster. If the individual has 20 or fewer coincidents with all members, he must have coincidents with at least two-thirds of the other members of the cluster. And individuals who have more than 20 coincidents with the 97, must have coincidents with at least three-quarters of the individuals in the cluster if they are to be admitted to it. Thus, it is clear that in order to insure that our clusters would be composed entirely legitimately, we were obliged to exclude from most clusters certain subjects who differ only very slightly from the admitted members in their card placement pattern.

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* A somewhat similar technique for grouping profiles came to our attention after we had finished processing our data. Sawrey, W.L., Keller, L., and Conger, J.J., "An Objective Method of Grouping Profiles by Distance Functions and its Relation to Factor Analysis," *Educational and Psychological Measurement*, XX, (1960), pp. 651-673. Also, cf. Cronbach, L.J., and Gleser, G.C., "Assessing Similarity Between Profiles," *Psychological Bulletin*, L, (1953), pp. 456-473, for a general criticism of the use of sigma-D^2 values in measuring distances between profiles.

Using these criteria, we then set out to build clusters. First, by observation alone, we selected apparent clusters from the matrices. Secondly, using the list produced by the computer, we systematically examined the progenerated group for each member of the apparent cluster to determine whether other individuals had a claim on membership in that cluster. And finally, we tested each cluster to ascertain that every member therein accepted could be certified as to his membership according to the criteria indicated above. In marginal cases, where each of two individuals tended to exclude the other (for every time a new subject is added to the cluster, the composition changes and the criteria become more difficult to satisfy) we left both off the membership list for the cluster. By these means, we constructed 9 clusters with from five to thirteen members. In all, sixty-four of the 119 original subjects are members of clusters. Several are members of two clusters, and one young woman, the one who had recorded 37 coincidents, is a member of three.

Two of the clusters are, on analysis, not very distinct, and are central to the group as a whole. Therefore, in the discussion in Chapter VI, these two clusters are treated as if they were one and the same. All of the remaining seven are treated separately in that chapter. The eight (as discussed in that chapter) are named as follows:

E1 and E2	The *Eclectic* - composed of 19 members drawn from the two most central clusters. In the tabular presentation below, these will be [illegible] 11 members, five of whom are members of E1. Eleven of the nineteen are experimentals and eight are controls. Seven majored in engineering and 12 in science. Their schools are: Brooklyn - 5; OSU - 7; and Stanford - 7.
Cv	The *Conventional* - composed of eleven members. Three members of this cluster are also members of the *Eclectic*. Four are experimentals and 7 are controls. Three majored in engineering and 8 in science. Their schools are: Brooklyn - 3; OSU - 3; and Stanford - 5.
A	The *Adolescent* - composed of 12 members. Two members of this cluster are also members of the *Eclectic*. Eleven are experimentals and one is a control. Seven majored in engineering and 5 in science. Their schools are: Brooklyn - 2; OSU - 4; and Stanford - 6.

S — The Societal - composed of eight members. Three members of this cluster are also members of the Adolescent. Seven are experimentals and one is a control. Five majored in engineering and 3 in science. Their schools are: OSU - 2 and Stanford - 6.

Co — The Cool - composed of six members. One member of this cluster is also a member of the Societal. Also, a mistake was made in card punching and it was discovered after the analysis had been completed that one member of this cluster does not technically qualify. However, he missed qualification by only a single sigma-D^2 point, which is so slight a distinction as to be almost meaningless. Five are experimentals and one is a control. Five majored in engineering and one in science. Their schools are: OSU - 3 and Stanford - 3.

OP — The Old Pros - composed of six members. One member of this cluster is an experimental and five are controls. This one experimental subject has not been considered in the general discussion of this cluster in Chapter VI because an examination of his interview suggests that his reasons for choosing cards may well have been pathological. Two majored in engineering and 4 in science. They are all OSU students.

A-I — The Anti-Ideological - composed of seven members. Five are experimental and 2 are controls. Four majored in engineering and 3 in science. Their schools are: Brooklyn - 1; OSU - 4; and Stanford - 2.

I — The Inscrutable - composed of five members. Two are experimentals and 3 are controls. Three majored in engineering and 2 in science. Their schools are: Brooklyn -2; OSU - 1; and Stanford - 2.

On Table 9, the Mean and Standard Deviation of the distribution of cards for each cluster is recorded in tabular form. The Mean indicates what cards were important for each cluster; the Standard Deviation, the degree to which the Mean represents the central tendency of the card. Generally, we have considered any card with a mean of 3.0 or less, or of 5.0 or more to be worthy of special attention. Table 10 records the sigma-D^2 distance between the Means of the 32 cards for the sample group as a whole and the nine clusters, and for the two sub-groups, experimental and control, and the nine clusters. And Table 11 is a matrix, giving the sigma-D^2 values between each of the nine clusters. It was on the basis of this table that we decided to treat the two Eclectic clusters (E1 and E2) as if they were a single group in the discussion in Chapter VI.

Table 9 - Means and Standard Deviation for Each Card for Each Cluster

Card#	E1		E2		Cv		A		S		Co		OP		A-I		I	
	M	Sd	M	Sd	M	Sd	M	Sd	M	Sd	M	Sd	M	Sd	M	Sd	M	Sd
1	4.9	1.14	5.9	0.67	[illegible]	1.19	6.1	0.64	5.9	0.62	5.7	0.95	5.3	0.75	4.6	1.05	4.6	0.81
2	4.4	0.84	4.4	0.98	2.2	0.72	5.1	0.78	4.4	1.13	5.2	0.69	2.7	1.11	3.7	0.70	4.2	0.75
3	4.7	0.99	3.6	0.98	2.9	0.79	5.1	0.76	4.9	0.62	4.7	1.25	3.8	0.69	4.1	0.64	4.8	0.40
4	4.9	0.73	4.9	0.90	4.0	0.74	5.4	0.49	5.5	1.00	4.7	0.95	3.5	0.76	5.0	0.76	4.0	0.63
5	5.0	1.11	5.0	1.15	4.2	1.19	5.8	0.83	5.6	1.13	6.5	0.50	3.0	1.58	4.6	1.40	4.0	0.90
6	3.1	0.87	3.2	0.83	2.8	0.72	3.6	0.76	3.8	0.66	4.0	0.82	2.5	0.95	2.9	1.25	3.2	0.40
7	3.7	0.82	4.2	1.03	3.4	1.07	4.8	0.85	4.9	0.62	4.0	0.82	3.8	1.06	3.1	0.36	4.4	0.81
8	5.8	0.70	5.9	0.79	5.6	0.77	5.4	1.28	2.6	1.00	2.5	1.12	6.0	0.82	4.9	1.25	4.2	0.75
9	3.2	0.77	3.1	0.79	3.0	0.42	3.5	0.78	4.3	0.66	3.7	0.75	4.0	0.58	3.4	0.91	2.8	1.17
10	3.3	0.72	3.5	0.50	3.7	0.75	3.8	0.69	4.1	0.62	4.2	0.69	3.3	1.11	4.1	0.84	2.8	0.40
11	3.2	1.05	3.3	1.14	3.4	0.64	4.7	0.95	3.9	1.18	3.8	0.69	2.8	1.06	4.1	0.64	3.0	0.63
12	3.9	0.83	4.5	0.66	3.2	1.03	4.1	0.86	3.9	0.62	4.2	0.69	4.2	1.06	2.6	0.91	4.0	0.63
13	3.8	1.10	3.3	0.87	4.4	0.89	4.3	0.74	4.8	1.09	5.2	1.07	3.5	1.12	5.7	0.70	3.4	0.90
14	4.0	0.56	4.5	0.66	4.6	0.89	4.4	0.59	5.1	0.62	4.3	0.75	3.7	0.75	4.7	0.70	3.8	0.66
15	4.5	0.63	4.5	0.50	4.6	0.77	4.3	0.63	4.9	0.78	4.0	0.58	4.2	0.69	5.6	0.50	5.0	0.90
16	3.8	0.86	2.8	0.94	3.1	1.08	4.4	0.49	4.1	0.78	4.2	0.69	4.5	0.50	4.3	0.88	2.0	0.00
17	1.7	0.82	2.4	1.07	1.5	0.66	2.6	0.86	3.0	0.50	2.3	0.75	4.2	0.69	1.9	0.35	3.2	1.60
18	2.1	0.48	3.1	1.08	2.7	1.13	2.9	0.86	3.6	1.13	2.0	0.58	2.2	0.90	2.4	1.29	2.2	0.97
19	5.0	0.56	4.8	0.83	5.0	0.42	3.8	1.32	4.3	1.20	4.8	0.93	3.7	1.11	3.3	1.01	3.8	0.40
20	4.1	0.99	4.0	0.86	3.5	1.31	3.2	0.98	3.3	0.44	3.5	1.12	3.5	0.95	4.0	1.07	3.8	0.40
21	6.2	0.70	6.5	0.50	6.3	0.45	4.4	1.44	3.4	0.70	2.8	0.69	5.0	0.82	4.3	0.88	4.6	0.81
22	5.3	0.99	4.5	0.90	4.8	0.57	4.0	1.09	4.1	1.58	4.5	0.96	5.2	0.37	3.3	1.03	4.2	1.72
23	3.8	1.39	3.7	0.97	4.1	1.17	2.6	0.86	3.1	1.05	2.8	0.93	5.7	1.11	3.0	0.93	4.8	1.17
24	4.1	0.99	4.9	1.24	4.7	0.75	3.3	0.74	3.1	0.33	4.9	1.47	4.3	0.94	3.6	0.91	4.0	0.63
25	3.5	0.93	4.0	0.86	4.4	1.30	2.7	0.75	2.9	0.62	3.8	1.21	5.2	0.90	4.1	0.64	4.6	1.02
26	3.5	0.75	3.6	0.98	3.8	0.57	2.6	0.96	2.6	0.70	3.8	1.07	3.5	0.50	4.4	1.06	5.4	1.02
27	3.3	1.06	3.2	1.47	4.5	1.23	2.4	1.19	1.5	0.50	3.2	1.21	3.5	1.36	3.0	1.20	5.2	1.17
28	3.5	1.28	3.6	0.77	4.4	1.07	2.8	1.26	2.5	1.00	3.7	1.25	3.7	0.47	3.6	1.18	6.0	1.27
29	3.8	0.77	3.2	0.83	4.3	0.97	3.8	0.59	3.9	0.78	3.3	1.11	4.7	1.11	4.6	1.06	3.6	1.07
30	4.7	1.20	4.1	1.08	5.5	1.08	4.6	1.18	5.3	1.59	3.8	0.69	5.7	1.11	5.1	0.99	5.6	0.81
31	2.9	0.92	2.8	1.03	4.4	0.89	4.2	0.69	4.6	0.49	4.2	1.07	4.0	1.00	5.6	1.06	2.4	0.83
32	4.1	1.14	3.4	0.77	4.9	1.14	3.9	0.47	4.4	1.00	3.8	0.69	3.3	0.75	4.7	0.70	4.2	1.17

Table 10

Sigma-D^2 Distance Between Base Points and Clusters

Cluster	Distance of Cluster from Total Population	Distance of Cluster from Experimentals	Distance of Cluster from Controls
Inscrutable	24.25	28.92	20.45
Conventional	15.84	21.21	10.44
Eclectic (E1)	9.87	11.08	11.29
Eclectic (E2)	13.09	15.42	13.25
Old Pros	20.70	27.16	14.35
Anti-Ideological	16.61	16.39	19.84
Cool	23.43	19.47	32.96
Adolescent	16.46	11.84	27.41
Societal	24.64	19.11	38.28

Table 11

For the matrix below, the sigma-D^2 distance between mean values for each of the nine clusters has been computed. The clusters have been ordered in the matrix in terms of their distance from the Inscrutable cluster which stands at the maximum distance from all other clusters.

	I	Cv	E1	E2	OP	A-I	Co	A	S
I	0	32.1	33.5	35.0	37.7	48.5	54.7	63.8	71.9
Cv	32.1	0	19.9	22.9	29.3	26.6	44.2	50.0	63.0
E1	33.5	19.9	0	8.8	34.5	32.4	38.8	23.6	42.9
E2	35.0	22.9	8.8	0	35.2	43.5	41.8	28.3	48.3
OP	37.7	29.3	34.5	35.2	0	42.5	67.7	54.8	65.7
A-I	48.5	26.6	32.4	43.5	42.5	0	35.9	31.0	33.1
Co	54.7	44.2	38.8	41.8	67.7	35.9	0	25.2	22.0
A	63.8	50.0	23.6	28.3	54.8	31.0	25.2	0	15.1
S	71.9	63.0	42.9	48.3	65.7	33.1	22.0	15.1	0

Section C

Conjectural Card-Sorts and the Comparison of these Sorts with the Findings

The three tables below, Tables 12, 13, and 14, contain the data necessary for the comparison between the card-sorts as made by Professor Friedenberg (indicated below as F's Sort) for each of the three hypotheses designated A in Chapter I and the nine clusters (indicated below, in sequence as E1 and E2 - the Eclectics; Cv - Conventional; OP - the Old Pros; A-Adolescent; S-Societal; Co - Cool; A-I - Anti-Ideological; and I - Inscrutable), the major sub-groups (indicated below as X-Experimental and C-Control), and the sample group as a whole (indicated below as SG). For convenience, the relevant hypothesis for each table is restated.

In Chapter VII we will utilize these statistical comparisons to analyze the relationship between our hypotheses and our actual findings. In that analysis, we will concentrate our attention on the cards that were distributed significantly by the members of the several clusters and the groups. For the groups, we will use as a measure of significance the limits as established by the T-Test and as introduced earlier in our discussion under Section A(1) of this chapter. For an infinite population (for our purposes generally, this means where N is greater than 30), the chances are less than one in one-hundred that a mean of more than 4.32 or less than 3.68 would have been recorded.*

For the sample group as a whole (SG), the cards that satisfy these criteria are:

Cards exceeding 4.32:	1, 4, 5, 8, 15, 21, 30.
Cards less than 3.68:	6, 9, 11, 17, 18, 26, 27.

For the experimentals (X), the cards are:

Cards exceeding 4.32:	1, 2, 3, 4, 5, 8, 15, 21, 30.
Cards less than 3.68:	6, 9, 17, 18, 23, 25, 26, 27.

For the controls (C), the cards are:

Cards exceeding 4.32:	1, 8, 15, 21, 22, 23, 30.
Cards less than 3.68:	2, 6, 9, 10, 11, 16, 17, 18.

For the clusters, we have depended less on statistical sophistication in determining significance and have conventionally discussed only those cards where the mean has exceeded 5.0 or has been less than 3.0. They are, as follows:

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* Cf. p. 25, above.

Cluster	Cards Exceeding 5.0	Cards Less than 3.0
Eclectic (E1)	17, 18, 31	8, 21, 22
Eclectic (E2)	16, 17, 31	1, 8, 21
Conventional (Cv)	3, 6, 17, 18	8, 21, 30
Old Pros (OP)	2, 6, 11, 18	1, 8, 22, 23, 25, 30
Adolescent (A)	17, 18, 23, 25, 26, 27, 28	1, 2, 3, 4, 5, 8
Societal (S)	8, 25, 26, 27, 28	1, 4, 5, 14, 30
Cool (Co)	8, 17, 18, 21, 23	1, 2, 5, 13
Anti-Ideological (A-I)	6, 12, 17, 18	12, 15, 30, 31
Inscrutable (I)	9, 10, 16, 18, 31	26, 27, 28, 30

Table 12

Sigma-D^2 comparison between Hypothesis A(1) as scored by Friedenberg and the nine clusters, the major sub-groups - experimental and control - and the sample group.

Hypothesis A(1) reads: Those who feel the most serious drawbacks to a scientific career to be conditions that they perceive as limitations on the free play of their integrity and spirit of inquiry. We have in mind such things as a conception of scientific method that excludes from consideration as data anything non-replicable or subjective; intrusions on the scientist's personal and political life by security programs; insufficient autonomy in planning work, or over-fragmentation of the individual scientific vision by the demands of large-scale, team projects.

F's Sort	#	E1	E2	Cv	OP	A	S	Co	A-I	I	X	C	SG
1	27	5.29	4.84	12.25	6.25	1.96	.25	4.84	4.00	17.64	4.84	7.84	5.76
2	18	.01	1.21	.49	.04	.81	2.56	.00	.16	.04	.81	.49	.81
2	25	2.25	4.00	5.76	10.24	.49	.81	3.24	4.41	6.76	2.25	5.29	3.61
2	26	2.25	2.56	3.24	2.25	.36	.36	3.24	5.76	11.56	1.96	4.00	2.56
3	9	.04	.01	.00	1.00	.25	1.69	.49	.16	.04	.09	.01	.04
3	11	.04	.09	.16	.04	2.89	.81	.64	1.21	.00	.49	.25	.36
3	13	.64	.09	1.96	.25	1.69	3.24	4.84	7.29	.16	1.21	1.44	1.21
3	20	1.21	1.00	.25	.25	.04	.09	.25	1.00	.64	1.21	.64	1.00
3	28	.25	.36	1.96	.49	.16	.25	.49	.36	9.00	.64	.64	.64
3	31	.01	.04	1.96	1.00	1.44	2.56	1.44	6.76	.36	1.00	1.00	1.00
3	32	1.21	.16	1.69	.09	.81	1.96	.64	2.89	1.44	.64	1.44	1.00
4	6	.81	.64	1.44	2.25	.16	.04	.00	1.21	.64	.36	1.00	.64
4	7	.09	.04	.36	.04	.64	.81	.00	.81	.16	.05	.04	.00
4	10	.49	.25	.09	.49	.04	.01	.04	.01	1.44	.04	.25	.09
4	12	.01	.25	.64	.04	.01	.01	.04	1.96	.00	.04	.01	.01
4	17	5.29	2.56	6.25	.04	1.96	1.00	2.89	4.41	.64	1.44	1.21	1.21
4	22	1.69	.25	.64	1.44	.00	.01	.25	.49	.04	.04	.16	.09
4	23	.04	.09	.01	2.89	1.96	.81	1.44	1.00	.64	.16	.25	.00
4	24	.01	.81	.49	.09	.49	.81	.81	.16	.00	.01	.04	.00
4	29	.04	.64	.09	.49	.04	.01	.49	.36	.16	.01	.04	.00
4	30	.49	.01	2.25	2.89	.36	1.69	.04	1.21	2.56	.64	.81	.64
5	2	.36	.36	3.24	5.29	.01	.36	.04	1.69	.64	.36	1.96	.81
5	3	.09	1.96	4.41	1.44	.01	.01	.09	.81	.04	.36	1.44	.64
5	4	.01	.01	1.00	2.25	.16	.25	.09	.00	1.00	.04	.49	.16
5	5	.00	.00	.64	4.00	.64	.36	2.25	.16	1.00	.04	1.00	.25
5	8	.64	.81	.36	1.00	.16	5.76	6.25	.01	.64	.16	.04	.04
5	15	.25	.25	.16	.64	.49	.01	1.00	.36	.00	.16	.36	.25
5	19	.00	.04	.00	1.69	1.44	.49	.04	2.89	1.44	.81	.49	.64
6	1	1.21	.01	4.84	.49	.01	.01	.09	1.96	1.96	1.21	1.44	1.21
6	14	4.00	2.25	1.96	5.29	2.56	.81	2.89	1.69	4.84	2.89	2.89	2.89
6	16	4.84	10.24	8.41	2.25	2.56	3.61	3.24	2.89	16.00	3.61	5.76	4.41
7	21	.64	.25	.49	4.00	6.76	12.96	17.64	7.29	5.76	6.25	4.00	5.29
ΣD^2		34.20	36.08	67.49	60.90	31.36	44.41	59.73	60.97	87.24	33.81	46.72	37.26

= Card number

Table 13

Sigma-D^2 comparison between Hypothesis A(2) as scored by Friedenberg and the nine clusters, the major sub-groups - experimental and control - and the sample group.

Hypothesis A(2) reads: Those who decide that they want more external rewards than they believe science will yield them: higher potential income, more personal power or status, a jollier peer group.

F's Sort	#	E1	E2	Cv	OP	A	S	Co	A-I	I	X	C	SG
1	12	8.41	12.25	4.84	10.24	9.61	8.41	10.24	2.56	9.00	7.84	9.61	8.41
2	3	7.29	2.56	.81	3.24	9.61	8.41	7.29	4.41	7.84	5.76	3.24	4.84
2	14	4.00	6.25	6.76	2.89	5.76	9.61	5.29	7.29	3.24	5.29	5.29	5.29
2	21	17.64	20.25	18.49	9.00	5.76	1.96	.64	5.29	6.76	6.25	9.00	7.29
3	1	3.61	8.41	.64	5.29	9.61	8.41	7.29	2.56	2.56	4.00	3.61	4.00
3	2	1.96	1.96	.04	.09	4.41	1.96	4.84	.49	1.44	1.96	.36	1.21
3	4	3.61	3.61	1.00	.25	5.76	6.25	2.89	4.00	1.00	3.24	1.69	2.56
3	5	4.00	4.00	1.44	.00	7.84	6.76	12.25	2.56	1.00	3.24	1.00	2.25
3	8	7.84	8.41	6.76	9.00	5.76	.16	.25	3.61	1.44	2.56	4.84	3.24
3	15	2.25	2.25	2.56	1.44	1.69	3.61	1.00	6.76	4.00	2.56	1.96	2.25
3	19	4.00	3.24	4.00	.49	.64	1.69	3.24	.09	.64	1.21	1.69	1.44
4	6	.81	.64	1.44	2.25	.16	.04	.00	1.21	.64	.36	1.00	.64
4	7	.09	.04	.36	.04	.64	.81	.00	.81	.16	.04	.04	.00
4	9	.64	.81	1.00	.00	.25	.09	.09	.36	1.44	.49	.81	.64
4	10	.49	.25	.09	.49	.04	.01	.04	.01	1.44	.04	.25	.09
4	11	.64	.49	.36	1.44	.49	.01	.04	.01	1.00	.09	.25	.16
4	16	.04	1.44	.81	.25	.16	.01	.04	.09	4.00	.01	.16	.01
4	17	5.29	2.56	6.25	.04	1.96	1.00	2.89	4.41	.64	1.44	1.21	1.21
4	18	3.61	.81	1.69	3.24	1.21	.16	4.00	2.56	3.24	1.21	1.69	1.21
4	22	1.69	.25	.64	1.44	.00	.01	.25	.49	.04	.04	.16	.09
4	24	.01	.81	.49	.09	.49	.81	.81	.16	.00	.01	.04	.00
5	13	1.44	2.89	.36	2.25	.49	.04	.04	.49	2.56	.81	.64	.81
5	20	.81	1.00	2.25	2.25	3.24	2.89	2.25	1.00	1.44	.81	1.44	1.00
5	23	1.44	1.69	.81	.49	5.76	3.61	4.84	4.00	.04	1.96	.25	1.00
5	25	2.25	1.00	.36	.04	5.29	4.41	1.44	.81	.16	2.25	.49	1.21
5	27	2.89	3.24	.25	2.25	6.76	12.25	3.24	2.89	4.00	3.24	1.44	2.56
5	29	1.44	3.24	.49	.09	1.44	1.21	2.89	.16	1.96	.81	1.44	1.00
5	32	.81	2.56	.49	2.89	1.21	.36	1.44	.09	.64	1.44	.64	1.00
6	26	6.25	5.76	4.84	6.25	11.56	11.56	4.84	2.56	.36	6.76	4.00	5.76
6	28	6.25	5.76	2.56	5.29	11.56	12.25	5.29	5.76	.00	4.84	4.84	4.84
6	31	9.61	10.24	2.56	4.00	3.24	1.96	3.24	.16	12.96	4.00	4.00	4.00
7	30	5.29	8.41	2.25	1.69	5.76	2.89	10.24	3.61	1.96	4.84	4.41	4.84
ΣD^2		116.40	127.08	77.69	78.70	128.16	113.61	103.13	72.37	73.64	79.40	71.49	74.85

= Card number

Table 14

Sigma-D^2 comparison between Hypothesis A(3) as scored by Friedenberg and the nine clusters, the major sub-groups - experimental and control - and the sample group.

Hypothesis A(3) reads: Those who expected science to be more directly concerned with human welfare and immediate problems of living than they find it to be; who expected to derive their principle career satisfaction from the experience of serving their clientele directly; who find it difficult to visualize the possible value of their work as simply an impersonal component of a process whose final human consequence they can never hope to see.

F's Sort	#	E1	E2	Cv	OP	A	S	Co	A-I	I	X	C	SG
1	24	9.61	15.21	13.69	10.89	5.29	4.41	15.21	6.76	9.00	8.41	10.89	9.00
2	19	9.00	7.84	9.00	2.89	3.24	5.29	7.84	1.69	3.24	4.41	5.29	4.84
2	20	3.24	1.44	5.29	7.29	3.24	3.61	1.69	6.76	2.56	4.41	3.24	4.00
2	30	7.29	4.41	12.25	13.69	6.76	10.89	3.24	9.61	12.96	7.84	8.41	7.84
3	6	.01	.04	.04	.25	.36	.64	1.00	.01	.04	.16	.00	.04
3	7	.49	1.44	.36	.64	3.24	3.61	1.00	.01	1.96	1.44	.64	1.00
3	12	.81	2.25	.04	1.44	1.21	.81	1.44	.16	1.00	.64	1.21	.81
3	17	1.69	.36	2.25	1.44	.16	.00	.49	1.21	.04	.04	.01	.01
3	18	.81	.01	.09	.64	.01	.36	1.00	.36	.64	.01	.09	.01
3	22	5.29	2.25	3.24	4.84	1.00	1.21	2.25	.09	1.44	1.44	1.96	1.69
3	28	.25	.36	1.96	.49	.16	.25	.49	.36	9.00	.64	.64	.64
4	2	.16	.16	.64	1.69	1.21	.36	1.44	.09	.04	.16	.16	.01
4	3	.49	.16	1.21	.04	1.21	.81	.49	.01	.64	.16	.04	.04
4	9	.64	.81	1.00	.00	.25	.09	.09	.36	1.44	.49	.81	.64
4	13	.04	.49	.16	.25	.09	.64	1.44	2.89	.36	.01	.04	.01
4	15	.25	.25	.36	.04	.09	.81	.00	2.56	1.00	.36	.16	.25
4	20	.01	.04	.25	.25	.64	.49	.25	.00	.04	.01	.04	.00
4	21	4.84	6.25	5.29	1.00	.16	.36	1.44	.09	.36	.25	1.00	.49
4	23	.04	.09	.01	2.89	1.96	.81	1.44	1.00	.64	.16	.25	.00
4	25	.25	.00	.16	1.44	1.69	1.21	.04	.01	.36	.25	.09	.01
4	27	.49	.64	.25	.25	2.56	6.25	.64	1.00	1.44	.64	.04	.36
5	1	.01	.81	1.44	.09	1.21	.81	.49	.16	.16	.00	.01	.09
5	4	.01	.01	1.00	2.25	.16	.25	.09	.00	1.00	.04	.49	.16
5	8	.64	.81	.36	1.00	.16	5.76	6.25	.01	.64	.16	.04	.04
5	10	2.89	2.25	1.69	2.89	1.44	.81	.64	.81	4.84	1.44	2.25	1.69
5	16	1.44	4.84	3.61	.25	.36	.81	.64	.49	9.00	.81	1.96	1.21
5	26	2.25	1.96	1.44	2.25	5.76	5.76	1.44	.36	.16	2.56	1.00	1.96
5	31	4.41	4.84	.36	1.00	.64	.16	.64	.36	6.76	1.00	1.00	1.00
6	5	1.00	1.00	3.24	9.00	.04	.16	.25	1.96	4.00	1.44	4.00	2.25
6	11	7.84	7.29	6.76	10.24	1.69	4.41	4.84	3.61	9.00	5.29	6.25	5.76
6	14	4.00	2.25	1.96	5.29	2.56	.81	2.89	1.69	4.84	2.89	2.89	2.89
7	32	8.41	13.96	7.29	13.69	9.61	6.76	10.24	5.29	7.84	10.24	7.84	9.00
ΣD^2		78.60	83.52	86.49	100.30	58.16	69.40	71.23	49.77	96.44	57.80	62.74	57.65

= Card number

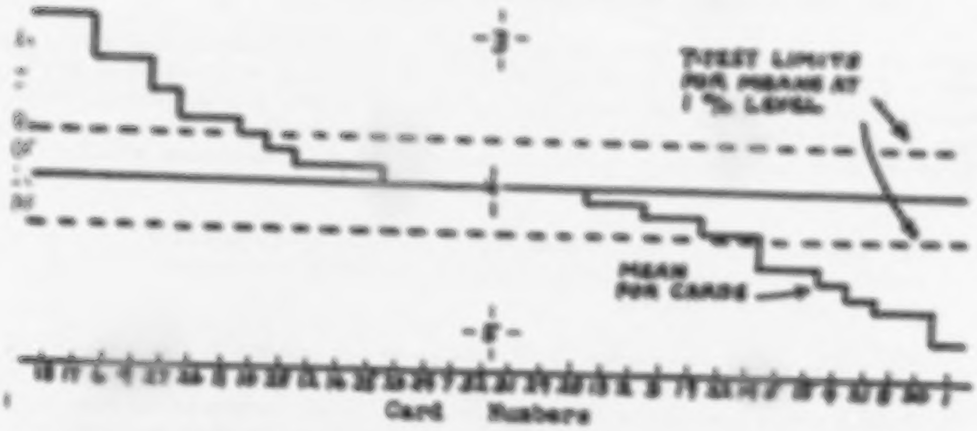
Chapter V

General Characteristics of the Sample Group

We shall describe what we found to be characteristic of our entire group of subjects before considering distinctions among them, but first a word of warning is needed. There is no basis for inferring that our 121 subjects are representative of all science students in the country. In fact, they could not be; because only half of those invited took part in the research, and science students who are willing to participate in an unfamiliar research project clearly have a different attitude toward science than those who ignored the request. Even though our 121 may be atypical in various ways, however, they are still of interest for what they are in themselves. A fact is still a fact, whether or not it can be generalized. The gallant story of Marat and Charlotte Corday is of itself enough to disprove the canard that eighteenth century Frenchmen never took baths.

For our subjects, there are two cards that stand out as overwhelmingly popular. This can readily be seen in Chart I, below, which gives the means for all cards as distributed by all members of the sample group. The cards have been placed on the chart in order of their acceptance or rejection by the sample group and cards #18 and #17, the two extreme cards in terms of acceptance, are on the left. Card #1, the most consistently rejected card, is at the extreme right on the chart.

Chart I -- Sample Group Profile



The two cards say:

> #18. Most scientific work today is carried out on more or less of an assembly line basis. Only the top scientists in industry or a few in university work are able to get on top of an entire problem; the rest of the "team" have to hammer away at their particular part of the job without really getting much of a "feel" for its overall purpose.
>
> #17. The work of the laboratory scientist is less varied and engrossing than the image of the pioneer serving mankind in his laboratory would lead you to expect. Most scientists spend most of their time in rather dull, routine activity.

Two other cards were almost as popular though the students tended more often to include them among their second choices than to make them first. These cards read:

> #6. In modern bureaucratic life, line always pulls more weight than staff, however competent or eminent. This means that scientists have to be prepared to accept having their most basic work subordinated to the demands of administrative policy.

> #9. Scientists don't get much chance to participate in making the decisions that govern their work. Once the project is set, they need all their creativity; but when it comes to having a say in where the whole project is going, they don't sit very high on the committee.

Card #27 is the fifth most popular card. Since it is also distributed atypically throughout the total range, it has a high Chi-square for its distribution, only being exceeded in this by the two most popular cards, #18 and #17.* Card #27 reads:

> #27. An interest in science is, to some extent, something many people in this culture ought to grow *through*. An American adolescent, if he has any spontaneous curiosity about the world he lives in at all, almost has to couch his interest in scientific terms, for these are the terms available. But when he gets far enough, he may well find that the questions science can answer are no longer the questions he must ask.

These are the statements which seemed most consistently important to our subjects. Except for #27, they are *not* statements that tend particularly to distinguish students who are going on in science from those who are leaving it. None of them produces a highly significant difference between these groups.

The cards that our subjects reject as silly or misleading, beginning with the one most consistently rejected, are:

> #1. Scientists make too little money in the course of a lifetime, compared to people in other professions, to justify the costs of getting a doctor's degree.

> #30. It is apparent that the conflict between science and the church, on which the Victorian Age reached a smug but workable compromise, has not really been resolved. The present role of science in the conduct of society suggests that when this compromise becomes unworkable through doubt about the essential humaneness of man, science is powerful enough to shove religion aside and ignore the questions that a responsible church must raise.

> #8. Scientists don't seem to live like other upper-middle class people even when they are quite successful. They tend to have fewer interests outside their work in things like the arts, or even in other people, so that life can get pretty dreary.

> #21. While there are many exceptions, groups of scientists are generally not as pleasant to be among as other intellectuals. On the whole, they tend to be stiffer and somewhat less broad-minded and sophisticated; they hardly seem to know how to enjoy themselves.

---

* See Table 6, p. 26 above.

#4. As professional people, scientists have to expect to move socially among people who earn just enough more than they do to keep them in a state of mild but unpleasant tension.

These five cards were generally unpopular. Only card #4 tended to be rejected more consistently by students who had abandoned science than by those who remained in it.

Taken together, these choices reflect an ideology that differs very much from the conventional stereotype of American youth. These youngsters are jealous of their autonomy, and ruefully aware that they may not have the strength to retain it within the organized system. Money they take for granted without making an issue of it; nor are they very anxious about what the neighbors may think of them. Of course, they were born after the Depression was over, and have always had nice neighbors. Conventional piety, religious or political, irritates them.

Here is how some of them put it in their interviews. Mr. Hughes, a big, good-looking, highly articulate Stanford junior, comments:

HUGHES: If you're going to do something you're interested in, you might as well base your education on your interests at the same time. I consider this rather a valid argument.

INTERVIEWER: It seems almost obvious to me.

HUGHES: Yes, so very simple. My mother doesn't see it as this valid, but this is irrelevant. ... (Hughes' father is deceased)

INTERVIEWER: Your mother was anxious for you to enter engineering, or what?

HUGHES: No, she was just worried that philosophy was highly out of date as a paying profession. This is the question I get from everyone, "Well, what in the world are you going to do?" and I smile and answer, "I don't know, and it really doesn't matter at the moment," because it doesn't. I'm considering teaching as a profession and I have a summer job as a teacher in prep school which I will find out just how I like it. ... I feel profoundly happier. I've well ... there's the little circle of all my interests and all the things I want to do, and then there was this other circle over there; what I was studying. Well, now and then I've just got one big circle, and I find that everything that I do, from every discussion I have over coffee on a casual date, or every book I read, every magazine, everything I hear, do and see is somehow related to everything I'm doing. ... (of engineering) I, as I said, was profoundly disappointed in all my classes. Math has been one of my best subjects all my life. It was quite easy for me. I had no trouble in the math courses; the same with the engineering courses. It just came easy, but it wasn't anything there -- like sand in soup. ... A lot of this comes from just realization -- it's just one awakening after another, and a lot of these interests I didn't know I had. I didn't know how much I was interested in literature or religion or philosophy because I'd not had an introduction to these and my life had been full of engineering. I hadn't read but about one or two books in four years.

....

INTERVIEWER: I'm interested in your present feelings about what it would have been like to stay in engineering and how -- what role these played in getting you to change to philosophy.

HUGHES: Well, my feelings are quite mixed about engineering. I still like it, strangely enough. ... There is a ... one side which is symmetric, geometric, mathematical, precise, scientific, orderly, plodding nature. This comes from, as I said, from four years of good engineering training. Then there is another side -- completely natural, unaffected, uninhibited, creative, expressive side. ... Now, I've been getting this engineering training all along and it's just been sort of natural. I like the engineering. I like math. Math, to me, is art. I like it. I like the way things work out and I like the engineering. I will still fiddle with it. I still have junk -- electronics stuff in my garage at home and, off and on, kick around with all the time. But the big thing is there's nothing there, nothing I can get my hands on, it's all ... it's all homework. ... It's -- there's a certain aspect to it, but it gets to be a drudgery and this is the thing that hit me when I came to school. There was just nothing there. ... It's just things that are not covered and I feel that engineering is ... would limit me too much. It was limiting. I wasn't getting the education I wanted -- the general background. ... They turn out quite good technicians, but as far as men, they're hollow, and I just don't like this.

....

I still don't know exactly what I want to go into and this sometimes worries me. ... But so, the inner struggle has pretty much settled. It was rough turmoil for a while, but, once I accepted it -- accepted the fact that I wasn't an engineer and accepted the fact that my interests were, in many ways wholly divergent from some of the people I had been associating with ... okay, I'm a little different. I have got other interests and things.

INTERVIEWER: Then the general feeling you have now is one of greater integration, is it, or ...?

HUGHES: Total integration. I said before there were two circles: there was my studies and my interests. Now, I have one and it's a considerably bigger circle. I have an awful lot of interests, but somehow they all tie in, and I feel this. I mean, it's just round; it's nice, inner calm, peace and perfectly satisfied. I know, in general, where I'm going, and how I'm going to get there. I know what I like and, in general, of course, this is always changing, it's expanding. I find more things. I open another book, learn something else, so there's nothing static about it. This is one thing I would dread, the idea of being static. ... It's not because I did not like engineering. I have an awful lot of respect for it, in fact, I have an awful lot of respect for the guys who can just, in a sense, throw away their lives and settle for just having things cut out for them and that's -- what time is it getting to be?

It was later than Mr. Hughes thought, and the interview came to an end. Mr. Hughes is not by any means the most typical of our subjects; he is more self-aware, rather more self-absorbed, and much better educated than most. Nevertheless, if he had not existed, it would have been necessary to invent him. These very characteristics make him an unusually rich and concentrated source of motives and attitudes we found among many of our sample.

Few of our subjects appeared less like Mr. Hughes than Mr. Rabinow, a Brooklyn College senior recommended to our study as one of the most promising young chemists in the graduating class of '59. In appearance, manner and volubility, Mr. Rabinow virtually represents the Brooklyn stereotype. Following the card-texts more closely than Mr. Hughes, Mr. Rabinow explains his choice of card #17:

RABINOW: Well, I've had opportunities, see, I work after school. I work for a big chemical company and I see what most research chemists are expected to do. ... Only PhD chemists do actual research. The way they set it up is most of it is dull routine, activity. Most scientific research, that is the nature of scientific research. I mean, once in a while you come up with an idea, I mean, that's the fascinating part, but then to go through the synthesis and the library work. I mean, that's actually a big part of science really, and that is dull and routine; and, I mean, people, I mean, I don't know, maybe a lot, I suppose there would be people that are taken in by thinking that there isn't much leg work and library work to it, but especially in science now, the literature output's so great, so it is pretty dull and routine most of the time. ... I suppose everybody says Hollywood type scientists are something glorious and that's not really true.

INTERVIEWER: Satisfactions have to come from something other than that, then?

RABINOW: Well, it's dull and routine, the work, but it leads to something (italics ours; not that this is just what Hughes no longer believes). I mean, you know you're going ... the work itself is dull and routine, then you get satisfaction after it's all over and accomplished.

....

INTERVIEWER: Then, in the next group of positive cards, #6?

RABINOW: Well, this again, as I say, is from experience, the way they work it at Healthmaster,[*] where I work ... at least the way it seems to me at my level. Certain research is done along medicinal purposes and they get up in the literature and somebody up in the -- usually the board of directors, they don't know much about scientific research, and they decide, well, some other company is coming out with some product -- let's say right now the big thing is psychic energizers. Well, we have to come up with something, too; so therefore, they tell the director of research, therefore, tells his different heads that we need a psychic energizer. And, therefore, whether you're interested in this type of work or not, you go down and get all the information you can on psychic energizers; go to lectures, do research work and try to synthesize something and they test it out and, I mean, this is really the ... administration is the big thing in what you do.

INTERVIEWER: The research director himself is a psychic energizer.

RABINOW: He's a scientist, the research director, but he's more of an administrative scientist, at least in this part.

....

I know I like a certain kind of recognition when I do a certain type of work. See, the work I do is nothing really, I mean, to be recognized, but on my level, naturally, there isn't any. But even on higher levels, it's always emphasized -- one man never gets the credit, it's always four or five mean have done it. Usually the -- I know this would bother me -- I mean, the -- usually the research director gets his name on it even though he had nothing to do with it, and then other people, you know, sometimes the vice president, they might stick his name on there, too, to show, you know, like a dedication to a symphony or something to your patron sort of kind of thing, and I just don't feel that this is right. ... In other words, you know, apple-polishing is very prevalent; if you want to get somewhere, you've got to be able to toe the line and show them that, you know, you're with them -- very little dissension. Everybody's smooth and calm. No arguments, no fights.

---

[*] A pseudonym for the firm for which Mr. Rabinow works.

A little later, during a discussion of the "responsible church" cards, #30, which he picked as the most misleading card, Mr. Rabinow rather diffusely makes a point that this is too high-flown an issue altogether, because for most young scientists, science is just a bread-and-butter task. Trying to paraphrase his comment on such *ideas*, the Interviewer evokes the following rather poignant misinterpretation:

RABINOW: If you work in industry, it's more so -- a bread-and-butter task. It might be before you go in, then maybe you can keep ... can have other ideas about ...

INTERVIEWER: Those are unlikely to survive, you think?

RABINOW: Oh, I don't know if they're unlikely to survive. It depends if they're smart enough to keep their mouth shut about their ideas and just do the work and then look for other kinds of satisfactions out of life, they'll be able to survive in science.

Ultimately, the Interviewer asks Mr. Rabinow whether the things that he expresses such strong dissatisfaction about in scientific work seem to him likely to make his chosen life-work unpleasant.

RABINOW: No, I've sort of become resigned to the fact ... let's say that I'm not particularly satisfied with my work now, but ... well, after I get out of graduate school, if I go back into industry, I don't feel that it'll be ... I don't expect -- let's say, I *hope* it will be different, but I don't expect it to be much different from now. I mean, the work that I'll be doing will be different, but as far as general attitude, the company, I don't think will be different. This is the way it is.

....

It's really hard for me to say exactly why, the general question, why I chose science. I never had a chemistry set. When I wanted to do some things, I couldn't do it at my house. I mean, my parents couldn't see it, you know. I did fool around a little bit, but right away they were on my back for fooling around. Once I even developed some pictures, and this annoyed my father because of the acetic acid smell; he didn't like it, so that was the end of that. ... I don't know, I was just curious about different things, and I thought that in science you have opportunity, really, to see a lot of different things ... really, you need extensive training. I try to tell myself, from the way I talk, I try to tell myself that the thing that I'm looking after in life is not a lot of money. That's the way I feel. (pause) I feel that I just want to make, naturally, a comfortable living and then devote myself to, oh, reading and learning and things. ... That's what I like to do. ... I also enjoy, well, working with my hands. I enjoy that and not as a hobby, but more as a career. I rather enjoy that. And science lends itself most to that. ... I rather like to work with my hands.

It fascinates me, and I get pleasure out of it. That's another reason why, well, where I worked I switched. Aside from the human factors involved, association, where I worked before I liked much better than down here ... I mean, at least there you did something, you made something, you had something to show for your work; here it's just ... I don't really even care what I do. I just do it and I get paid and that's it.

....

Anyway, it's remarkable the way things fit in when I look back, because I wasn't ... I was planning on going to college, see, but not full-time day school. I never thought I could do it. 'Course, I had to work, I mean, I had to support myself and had to support my mother also; I mean, it was just ... I couldn't do it. But I got this job, this work ... I don't know what you want to call it; God, fate, whatever you believe in, but through high school I got this job where I work now, and when I started to work there it just so happened, well, I mean, they had students working there who were working nights and going to full-time day school, and they said, "Well, why don't *you* do this?" and I said, "Why not?" ... and I started to go to day school, that I had originally planned on going to night school. And everything worked out for the best. ... (*sotto voce*) best of all possible worlds.

More simply perhaps, Mr. Grant, a young adult Western from Stanford, comments on his change from engineering to political science:

GRANT: Well, my personal reason for my own changes were, well, originally, when I wanted to come to Stanford, I wanted to come to Stanford because ... though at the time I thought I wanted to a scientific or technical education, I did want to come to a university where I would get a good, some good liberal education; and as I got here, I discovered I was more interested in what they were teaching in the liberal field than what I was getting in my scientific field and then, at the start of my junior year, when I should have been maturing in my views toward my scientific education, I found that other students who I knew were maturing in it more and taking it more -- of a kind of attitude you were supposed to take. But myself, I still had the desire to -- oh, more towards ideas in philosophy and political science and my ... as far as a career is bound, when I changed, I threw away virtually a set career and a job in companies I could have gone to work for, knowing that what I was going to study now was what I wanted to study. I'd just take a chance on what I'd find. I figured I'd find my place.

....

Another thing, my experience in summer work, which was in construction and very closely related to the field I would have gone into, I consider more valuable, from a practical standpoint, in the way you figure out things than the way they go at it in the classroom situation. And these friends of mine, they were also engineers, they just took to this in a way that was just foreign to my nature because I've seen too many people -- young engineers in jobs, I've worked with them -- who come out and know it right out of the books but don't have the slightest idea how to get a job done. And I turned away from this and I knew that I could never be that way and I began to kind of re-examine what I really wanted; I found that engineering wasn't really what I wanted. I've always, ever since I've been here, I've always entertained the thought of shifting over into political science or philosophy. So finally I decided it was time to get out ... I'd rather get the kind of education that would do me ... that I'd feel would do me the most good in the long run, and that is a broader, liberal education.

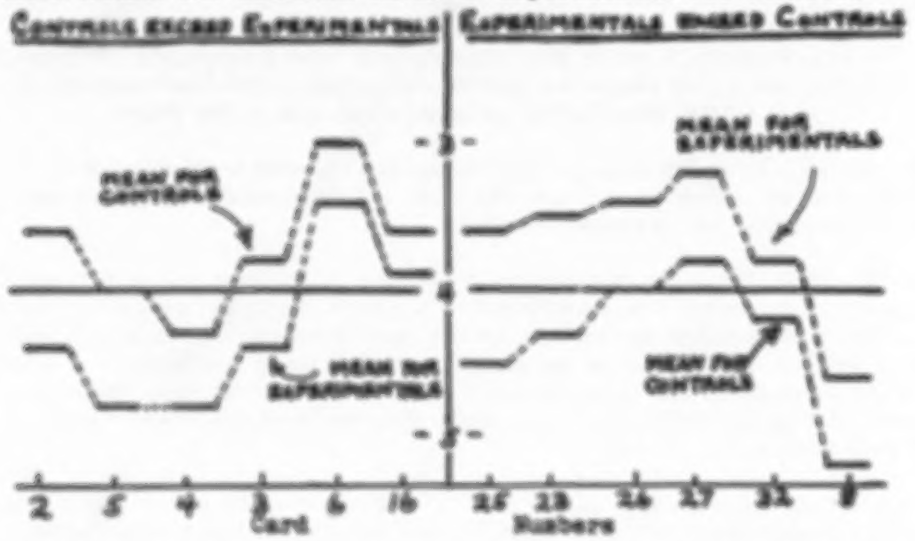
INTERVIEWER: Yes. Do you what sort of good?

GRANT: Just being more (pause) ... this is the question, because the things that I figure are ... have come to figure are least important is the economic angle, because I figure that if I can get the liberal education, why, I can make a living anyway; if you've got a college degree, you stand a reasonably good chance of making a living. I'm not out to get rich in this world, because there's so much of this world that I don't understand and want to find out about; and I don't think you find it in math books or engineering books. And I know I'll probably never find it, and I know it's very, very easy to think about these things; that you ... the same criticism that I apply to engineering applies to liberal education. It's very easy to be all involved with these ideas while you're in school, but I can sit around in a discussion and talk about these ideas and philosophies and different things, and you can walk right out, and never think about them again. I'm just more interested in the ideas of politics and political action and theories of government and the way men are, the way men work, why men do things, than I am in building roads for men to drive on. That's it. It's a great way to make a living -- to be outside and whatnot -- and it's a challenge; but people are a greater challenge. ... Apparently that's ... that's something ... what do people in this country really need, and what do they really want? It seems like all they're they're really interested in is a swimming pool and a boat to take out on weekends. Looks like that. Now, maybe this is right and maybe this is wrong, but, still, I think the very fact that we do have our high standard of living and we *are* the leading country in the world obligates us to some concern over the other peoples in the world, and there are so many other people who do not feel this way. ... I think this obligates us to concern over the rest of the world even if we weren't faced with the challenge of the East -- Russian ideology. ... I don't have any false illusions about going out on any big campaign of any ideal, and that's just it. I'd like to try and sell these ideas or try and influence a few people, but yet, I really don't know whether my ideas are as yet that important or that good; and if I should come to the conclusion that I did have some ideas that could be of some use, I really don't know how I could go about trying to spread them. ... I came here myself because I know the only ... to get a college education is the way to make a better living. ... I mean, I have to get out and work to make the money to come to school, but I don't think that everybody in this world is going to be able to get rich and I think that what we do have now -- our living standard is high enough that nobody is really suffering from that much want in this country, where a lot of other places, a lot of people are. ... This way, I don't ... at the present time have the same connections and ins, but I think I'll find what I'm more interested in here. I don't know where it'll lead me; lead me along the lines I'm more interested in following.

These three young men, each unique, epitomize the attitudes that run through much of our sample, though they express them more movingly than most. But these attitudes are characteristic both of those who leave science and those who continue in it. What *distinguishes* those who leave from those who stay?

Chart II

Mean Values for Selected Cards -- Experimental vs. Controls



For the chart above the cards are selected on the basis of the distance between means stated in terms of the standard error. In these terms, Cards #2 and #25 are the extreme cards. The T-test score for each of the 12 cards is significant at the 5% level. The cards discussed in the text below are the seven which are significant at the 1% level. Cf. Table 7, pp. 28-29, above.

Only seven of the 32 cards elicit sharply different responses from the two groups. They form a suggestive pattern. Three of the cards deal, like card #1, with whether scientists get enough money to justify the time and trouble of their training. But they raise more specific issues about this than the highly unpopular card #1. Card #2 and #3 read:

> #2. Scientists' salaries may seem high enough usually, but since they usually work for a company or university on a pure annual basis, they have much less chance than doctors, say, or lawyers, to do well for themselves.
>
> #3. Over a lifetime, perhaps, a person with a PhD in one of the sciences will earn about as much as other professionals; but it takes him so long to get up there with the others that he and his family have quite a struggle.

Card #4 has already been quoted (page 45). Students who had left science tended to *reject* these cards more severely than those who were continuing. The control group, by contrast, were more willing to admit that these might be legitimate complaints against a career that nevertheless appealed to them on balance. When control subjects *did* reject these cards, they were more likely to do so on the grounds that they were misleading, out of date: scientists now get plenty of money, especially if you count in grants and "perks." Students who had abandoned science, however, usually stressed that the money was just not that important to them.

Card #5 was extremely unpopular with the students who had abandoned careers in science; the control group distributed it almost as they would have by chance. It reads:

> #5. People are really pretty ambivalent toward scientists. Officially, they are highly respected, but the stereotype of the mad scientist is seldom wholly absent from the mind of the man in the street.

Mr. Dove, a Brooklyn College student who had changed from physics to English, and who chose #5 as his worst card, put quite succinctly the reason most subjects give for rejecting this card:

> DOVE: Well, I pick the fact that the stereotype of the mad scientist is not important; it shouldn't be important to a scientist at all, because I felt that a scientist should just have a love for his work if he goes into it at all, and so, even if there was such a stereotype -- I don't know that there is -- this should not concern him in the least. ... If you divide it this way, thinking about what people think about your work, then you've lost already a piece of your enjoyment.

Hardly anyone who rejected this card did so because they thought it was a false statement. Generally, they did think so, but just did not much care whether it was or not.

The remaining three cards that sharply distinguish the students who have left science from the control group are all cards that the former science students favor as important pieces of advice. And all deal with different aspects of the same issue. One of these, #23, the control group dislikes and rejects. At the extremes, the contrast is very marked.* Two of the ex-science group pick this as the best card, none pick it as the worst. Three of the control group pick it as the worst; none as the best. It reads:

> #23. Contrary to what one usually expects, scientific training actually seems to offer little encouragement to independence of thought. There is more lecturing and less discussion than in other disciplines; the examinations tend to be rather petty and factual. Even the lecturer's jokes are listed in the syllabus.

Card #25 is also rejected sharply by the members of the control group. It reads:

> #25. The scientific method, as it is taught in the classroom and thought of by the general run of scientists, actually hampers efforts to understand many problems. Insight into the way things develop, and their unique, particular meaning, are sacrificed to rigid experimental control and statistical generality in order to keep the research scientifically respectable.

The control group scatters card #26 in a chance pattern; most of the ex-scientists are solidly behind it. It reads:

> #26. The scientist's commitment to place objectivity first, while it has made science the instrument of empirical mastery of the environment, ultimately limits his power to penetrate to fundamental meanings. With so much of human experience

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* Cf. Table 7, pp. 28-29.

> tending toward depersonalization, it is just those perceptions that cannot be "consensually validated" that are often of crucial importance.

The general tenor of Mr. Hughes' and Mr. Grant's quoted comments illustrates the feeling tone that underlies the positive selection of these cards. Sometimes it is less idealistically expressed, as in the comments of Mr. Perry, a bright, personable Ohio State senior who switched from engineering to business management, on #23 as his first choice:

> **PERRY:** If this guy was going into engineering with the idea of gaining indepen ... of being independent and having a broad concept of things ... the subjects he's going to be taking are very limited and I didn't think they encouraged really independent thinking. What they encouraged was the ability to, well, deal with specific mechanical processes in solving problems. ... There again, the examinations, it's important that you remember the formula, not that you have some grasp ... of broad, general things. Anyway, like in history, where you'd want to have a broad, general understanding of why something happened, and what its implications are. But in most of the examinations in engineering, if you forgot the formula, well, you just don't solve the problem. Which puts a premium on memorizing certain mechanical things. ... It doesn't really lend itself to general discussion because , well, there's not much question about it; he's coming in there to tell you facts and show you how things work and you can ask him to maybe explain something, but you don't really question it.

By contrast, Mr. Wheeler, one of the most successful engineering students rates #23 as the one worst card. Yet, in his comments, he agrees fairly well with Mr. Perry as to how things are. The contrast is largely between Mr. Perry's short-term irritation and Mr. Wheeler's long-range identification with his vocational goal:

> **WHEELER:** I think actually lecturing, discussing a topic, the more familiar the scientist's professor becomes with his subject, as far as I can see, the more prepared he is to do basic research. It has to get to be so that he knows these facts and principles upside down, backwards, in his sleep. And I feel that through lecturing and discussion, why, he can learn it this way and research will come more naturally.
>
> **INTERVIEWER:** And there is adequate discussion, then, as well as ...
>
> **WHEELER:** Yes, I believe so. If we're referring to the classroom, possibly, student, I believe there's every opportunity for the student to bring up any questions he has.
>
> **INTERVIEWER:** Do you think it's true that there is more opportunity in arts and such?
>
> **WHEELER:** Well, possibly there is more opportunity for discussion in the arts, but that probably stems from the fact that so many of the arts questions are not, actually, don't have one answer, while such things as two and two is always four. There's not much discussion you can carry on about it.

The subjects who leave science and engineering are insistent that their feelings are the source of their integrity. They must, therefore, demand respect for them and act them out at once. The students who remain may be equally critical of the limitations of scientific truth and of the society in which they must function --

though they generally are not as critical. But they are either less confident of their ability to find any spot outside the system in which they would be any freer than they would be in science, or more confident that if they accept the system they will ultimately find themselves within it. Some rather combine these two feelings, like Mr. Byron, a Stanford electrical engineer: young, married, cool; bright and sharp as a hound's tooth.

> BYRON: I don't think it's the best use of me, but I'm in it now -- up to the hilt. I mean, you know, after you get two years of school. I'm perfectly satisfied. I enjoy myself in electrical engineering; it's just that I would have enjoyed myself more in other fields. And I do have quite a bit of pleasure in the simple challenges. You know, I wouldn't want to be a writer or any -- well, I mean, I'd like to be but I also get a lot of enjoyment out of engineering, too. ... I do like the technical side of engineering. It's just that I wish there were more of a creative aspect to it than there is. I won't be unhappy in engineering. ... I don't enjoy being with purely intellectuals, either.
>
> INTERVIEWER: That has too much of a, what -- a North Beach flavor?
>
> BYRON: Yes, I think, well, yes, sort of. People that are for Adlai ... madly for Adlai and join political causes. Really intellectual people tend to be a little narrow-minded in avoiding these barbecues. ... I'm for Adlai myself, but not madly. ... There was the funniest headline: "Nixon will try to run as an individual if nominated." He's not going to run as an elephant, he's going to run as an individual, if he possibly can.
>
> INTERVIEWER: Card #23?
>
> BYRON: Well, it's true. What's there to discuss?
>
> INTERVIEWER: Then, your most extreme negative card, card #5?
>
> BYRON: Yes, I think it's silly. So what? Who is the man on the street? You just, just don't go fiddling around with the man on the street if you're a scientist.
>
> INTERVIEWER: Any other comments you'd care to add?
>
> BYRON: No. I think I've discussed my reasons for being slightly down on scientists. Definitely an interesting profession; it's just that these people get a slight case of narrow brain. That's about it.

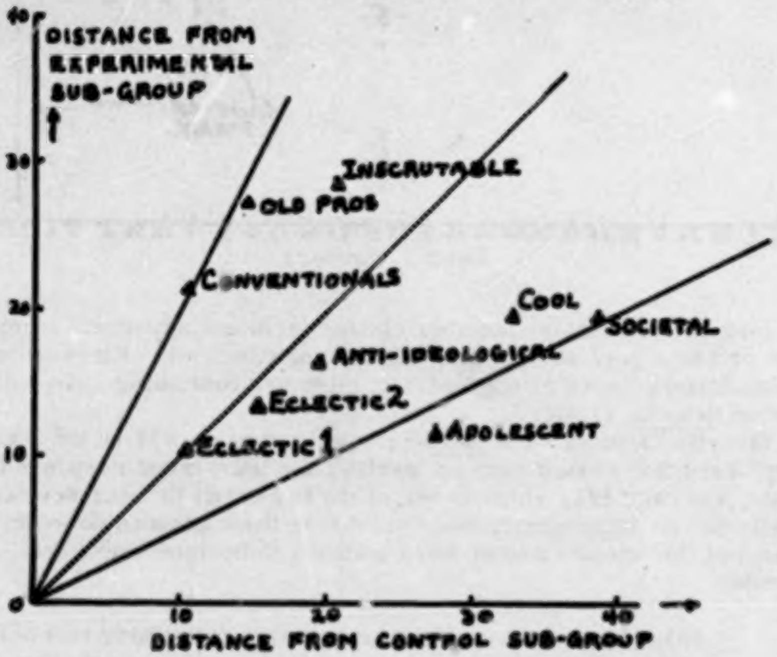
In Mr. Byron's manner there was nothing at all supercilious or snide. A wiry, bronzed, clean-shaven young man, clad in a sport shirt, jeans, and a pair of *zori*; he broke the toe strap on one of these by the ardor of his gestures during the interview. "May I?" he inquired politely at the end; and, dropping the *zori* into the wastebasket, strode out of the research office and into the Western world, barefoot.

Chapter VI

Descriptive Analysis of the Clusters

In portraying the relationships of the various clusters to one another so as to compare them most clearly, problems that are essentially cartographic arise. As in mapping the surface of the earth, any convention we choose distorts some aspects of the relationships; none is topologically perfect. Chart III, below, on which clusters appear on a plan relative to their sigma-D^2 distance from the major sub-groups - experimental and control - is only one of several plane surface projections possible. As such, it demonstrates very clearly that the double Eclectic cluster is central with respect to the two major sub-groups as well as to the smaller clusters.* For this reason, we have begun our discussion of the eight clusters with an analysis of the Eclectics.

Chart III
Placement of Clusters
in Terms of their Sigma-D^2 Distance from
the Experimental and Control Sub-Groups



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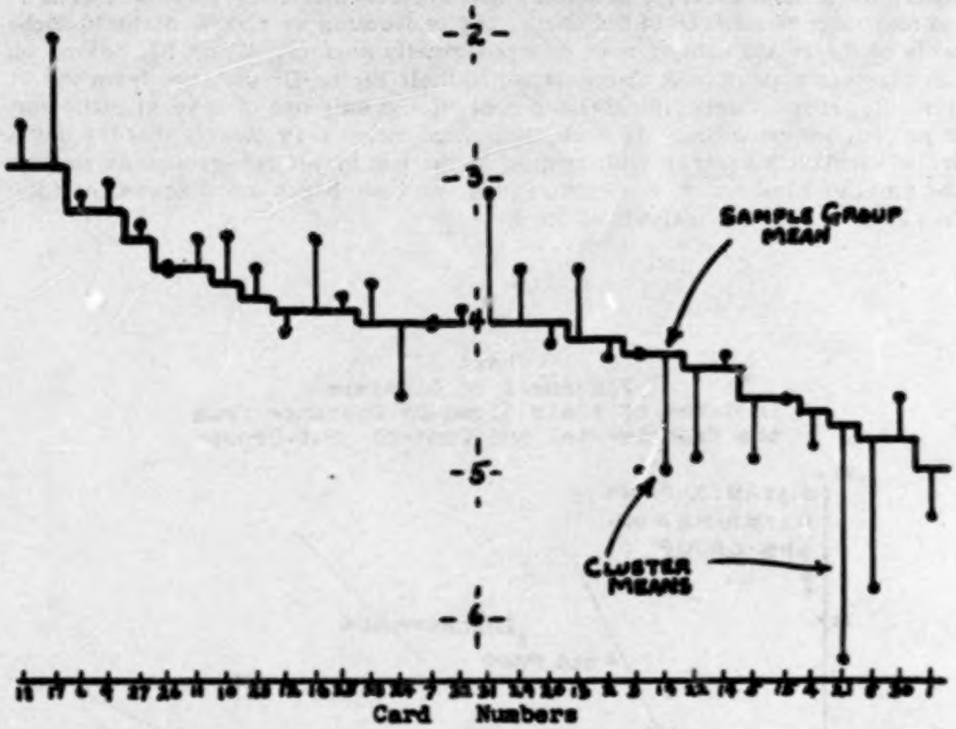
* Cf. Tables 10 and 11, p. 37.

(A) The Eclectic Cluster

Chart IV -- Eclectic Cluster Profile



The largest, or nineteen member cluster includes individuals from all three schools and both pure science and engineering curricula. Eleven cluster members have abandoned science or engineering; eight are continuing. We will call this group our Eclectic cluster.

The favorite cards of the Eclectic cluster are cards #17 -- the "dull, routine activity" card that evoked such an involved and ambivalent response from Mr. Rabinow, and card #31, which is one of the two cards that our science subjects generally see as significantly more valid than the engineers do -- though seven members of this cluster are or were planning to become engineers. Card #31 reads:

> #31. The costs of scientific research today have tied science so closely to the purposes of elite groups in society that it has abandoned most of its critical and skeptical function. When you are dependent on tax exemptions and foundation grants in order to get your work done, you get to be pretty careful never to catch Truth in embarrassing commerce with Mars or Mammon.

Cards #8 and #21, quoted above as among the least popular cards for the entire group, were significantly less popular for the Eclectic cluster than for the total sample. These are the cards that portray the scientists as stiff people who lead dreary, threadbare lives -- a point of view our Eclectic cluster rejects very strongly.

Since the nineteen subjects of the Eclectic cluster come from all parts of our sample, what is it that they have in common; what makes them a cluster? Mr.

Rabinow, quoted at length above, expresses very clearly the attitudes that seem to underly their card choices. On the one hand, there is a compelling -- almost a compulsive -- identification that leads the subject to insist that he likes science and scientists, whether he himself is going on in it or not. On the other hand, there is a nagging preoccupation with the daily annoyances of scientific work under the conditions in which it must actually be done. The Eclectic cluster is mundane in its attitudes and concerned with the realities of the scientist's or engineer's working life, but its members are not happy about those realities as they see them; too modest or not confident enough to make large claims for the authority of their inner life, they nevertheless display that life vividly in their reactions to condititions they hardly hope to transcend. They may continue, as Mr. Rabinow is continuing, in science; but their level of aspiration is low; they haven't much hope of attaining distinction. The possibility hardly seems real to them; an Ohio State member of this cluster, continuing in geology and doing extremely well in it, speaks of his burgeoning career:

> INTERVIEWER: What, then, about your overall feeling? Are you happy, I take it, that you are making a career in geology, or would that be making too strong a statement?
>
> SUBJECT: Oh, I don't know. I like to study geology, but I'm nost sure yet exactly what field of geology. And I don't know. I'm afraid that if I'm married soon and have a family, I might just have to drop geology just to work, so I could make some money.
>
> INTERVIEWER: And you don't feel geologists have ...?
>
> SUBJECT: Well, there isn't much of an opportunity now. I only have a BS now this March and chances are practically nil with me getting a job working as a geologist; I could, with a Master's degree or a Doctor's degree, and I'd like to do that. But I think I'd rather teach geology in a university, because if I go to work for a private company, then it's going to be (word lost) not going to be able to do what I want to do and might end up doing something that I actually hate.
>
> INTERVIEWER: You have an extraordinarily high average (A-) in your work, though.
>
> SUBJECT: Oh, I like it. I don't mind studying it. I like to study.

This begins to give a clue as to how it is that both former science and control subjects fall so easily into this cluster. The control members, by and large, are continuing rather passively in a field about which they have misgivings, letting "I dare not" wait upon "I would," like the poor cat in the adage. The experimental members of the Eclectic cluster, though perhaps more sensitive to petty details of their experience as science students than to larger values or epistemological issues, at least have the ego-strength and detachment to make a break. Mr. Eero, a stalwart, roughly handsome ex-engineer of Finnish stock, falls into this group. Present at his interview was another Stanford student, a former biology major, Mr. Harcourt, who does not fall into the Eclectic cluster, and whose loftiness seems sometimes to annoy Mr. Eero. The discussion is about Mr. Eero's first choice, card #17:

> EERO: One reason I chose this is because I think everybody, when thinking of a profession, tends to glamorize it. There is a lot of routine to any kind of job.

HARCOURT: I think that this is a rather naive way to look at the sciences, that those who spend, those scientists, quote, unquote, who spend their time doing dull, tedious tasks are only those who are working in the sciences at the same level of competence as those who would be doing dull, tedious tasks in any line of work. I think that one's attitude toward another one's profession has to be very closely correlated to the level of competence at which one is engaged.

EERO: I think of people like Madame Curie, for instance and her husband, who worked for I don't know how many years shoveling pitchblende around ...

HARCOURT: (scornfully) But I hardly think that if they were on the track of something that it would have been dull and routine, or they would have quit.

EERO: No ...

HARCOURT: It might have been routine, but really not dull.

EERO: Well, maybe dull is a bad word, but I think it was certainly routine and tedious.

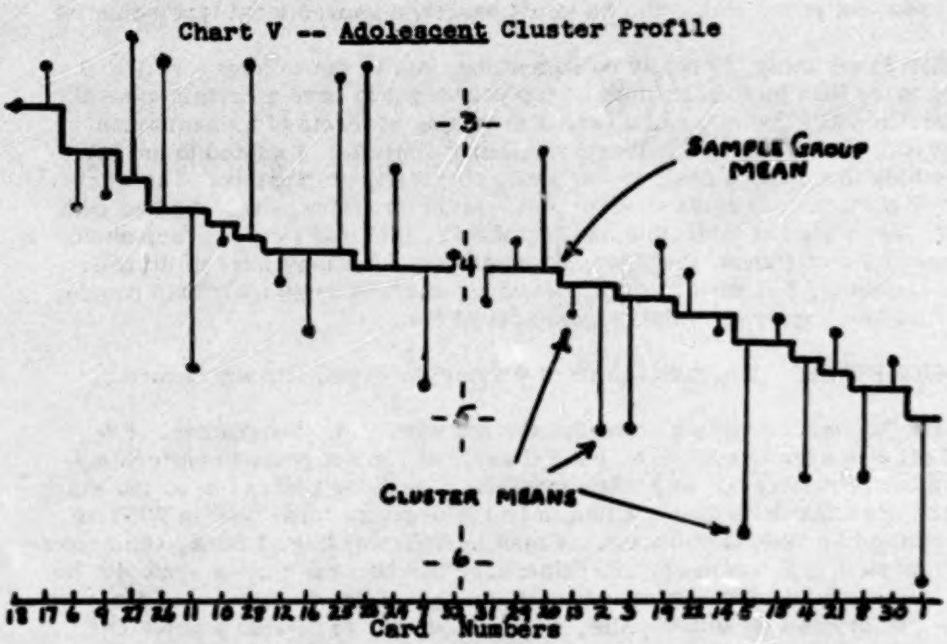
HARCOURT: And tedious -- but not dull; and so, one's view of the laboratory scientist, I don't think, only at a very mediocre, mechanical level, would it be dull.

EERO: All my experience has been that science requires a great deal of precision, and precision sometimes for precision's sake. And, thus, there is a certain going over of things. I think there is a certain amount of scientific work that is dull no matter what level you reach. Even a guy like Einstein has to sit down and work out mathematical formulas, go through a lot of pages and pages of work, and I imagine there are times when they wish they could skip that part. .... This is to tell someone who you're talking with who's thinking of choosing science. Now if a person is ... there are people happy doing things that I couldn't do for two minutes and this is something that a person has to look into and not glorify science as standing in a white coat and "Eureka!" because very little of it is that.

The Eclectic cluster is not just the largest cluster yielded by the methodology of the study; it is the most central. Its characteristics do not contrast with those of the total group so much as they emphasize certain of them. The popular cards #26 and #27, that warn against the tendency of science to deny subjective truth are distributed within the Eclectic cluster very much as they are by the total group of subjects. But the Eclectic cluster is especially troubled about the daily ennui in a scientist's life, and especially reluctant to imagine that ennui transcended by noble vision or purpose, or by heroic individual capacity. No man is a hero to the Eclectic cluster. Which is, after all, the way we live now.

(B) The Adolescent Cluster

Chart V -- Adolescent Cluster Profile



There is a subsidiary and somewhat less clearly delineated focus of central tendency in the total group. This is a cluster of 12 individuals, with a related satellite cluster of eight, three of whom are also members of the twelve. Two members of this twelve subject cluster also fall, by virtue of other portions of their card-choice pattern, into the Eclectic cluster. Topologically, that is the twelve subject cluster is still fairly near the center of the total group, while the satellite lies on its far side, and includes its most far-out members.

We call this 12 member cluster the Adolescent cluster because its members share a common preoccupation with their own identity and their peculiar perception of the meaning of life. They talk about what it means to be them endlessly, enthusiastically, and also refreshingly and well. Their archetype, who is also a member of the satellite cluster, is Mr. Hughes. Mr. Perry is also a member of both clusters; Mr. Grant is a member of the Adolescent cluster, but just barely fails, by our statistical criteria, to get into the satellite.

The Adolescent cluster emphasizes cards #23, #25, #26, #27 and #28 far more than most subjects. All these have been quoted before except for #28, which reads:

> #28. It is naive to assume that the scientific method leads to the discovery of the kind of truth that is of most fundamental importance. Empirical research is of the greatest value as the instrument of prediction and control of nature, but it is on untestable transcendental or theological concepts that life ultimately depends for its meaning.

These five cards all warn against various ways in which scientific rigidity may exclude or impose upon elements of intuition or poetic vision. Twenty-seven is generally a popular card, though not as popular as it is with the Adolescent group. But #23, #25 and #26 have all been quoted as cards that the former scientists regard as very sound advice, while control group subjects ignore or reject them.

It follows, then, that the Adolescent group must be composed largely of youngsters who are lost to science; and it is. Only one member of it -- Mr. Bond, of Ohio State -- is still in a scientific field. Mr. Bond is a healthy-looking, jolly, crew-cut young man. But he is not exactly a conventional-type scientist.

BOND: In my mind, to really do something, you've got to have a skill. It takes more than just aspirations. And you've got to have a certain amount of specific skill that you can offer. I'm talking in terms of humanitarian endeavor, if you want. So, therefore, being realistic, I wanted to get into something that I could deal, if you want, physically or tangibly. The ministry or medicine, it came down to that. In the ministry, I was dealing with things that were too intangible and just didn't seem that I could grasp ahold of them. I didn't know what I was doing exactly. I wasn't sure of myself. With medicine, I'm sure I've got something whereby I can truly help people, and I'd like to apply it on the largest scale I can.

INTERVIEWER: You didn't think of playing the organ, by any chance?

BOND: No, you're talking about Schweitzer now. No. Schweitzer. I've read all of his books and such, but I'll say that I'm not going to pattern myself after Schweitzer or any other man, because I don't intend to do the exact kind of work that he's done. I like to be the organizational type in WHO or something like that, if you want. A man in WHO working, I think, can accomplish more than Schweitzer. ... Schweitzer has become quite a symbol. He has, there's no doubt about it. A young man, you like to think -- at least I do -- "What can I do with my life, which I consider to be really valuable?" And at the end of fifty years of living, I want to say, "Now, what have I accomplished?" in certain terms. And to me, service is the biggest concept. It really is. Along with, of course, in the end, I'm trying to achieve personal happiness. Let's not get away from that. And this is just my definition of the way that I'm going to achieve it. ... I'm going to medical school next year. I'll be through in medical school in four years, and then I'd possibly like to do travelling for maybe four years or so. I'm serious. Just on an adventure kick, if you want, and then settling down for thirty years to some specific application of what I know.

INTERVIEWER: Won't you have to take your internship or residency?

BOND: Surely, but I can also tie this in with a romantic adventure somewhere. Because I can very easily possibly go to a foreign land, and, actually, this could help me in doing what I want to do, if you use it that way.

....

Science is not an end in itself to me. It's merely, once you go far enough in science, I think that you do have to jump again to other questions, because I think science stops, and, if you want, philosophy and a lot of other questions begin to pick up a little bit. And I couldn't. I think you could say that I'm a scientifically trained person with goals which are strictly not scientific research, but an application of science to man, so I guess you would call me, well, a humanist.

....

When I have, for example a course which makes me think in my own terms and new ideas, I do extra reading and everything. Well, for science, I just read the syllabus, and I memorize the muscles and such. So, independence of thought; if one just took science courses, I'd feel like he was just regurgitating. Until you reach the state, now ... that might take me toward research eventually, way further on, that you know science so well there's no more regurgitating. From there, it's newness; and if I could find newness in science there'd be a real challenge.

....

INTERVIEWER: Is there anything of a more general kind (that is, not bearing on specific card choices) you would care to add?

BOND: No. This has been interesting though. It's been very interesting to be able to sit and analyze. I've thought about this ... *or else I would have switched out of the curriculum of science which I'm now in.* And I couldn't go ahead and be a doctor. I'd become a philosopher, but to me, being a philosopher all of your life isn't achieving what I'd like to achieve very generally. There is a temptation for a young man, I think, once you begin to be exposed to thinking and to new thoughts and to philosophy and to more general readings, and Tillich and a few other gentlemen, to want to do more thinking and less learning of facts. Original thought. And I'd like with science to lead an original life. Not a life stereotyped on Schweitzer.

INTERVIEWER: Like your own?

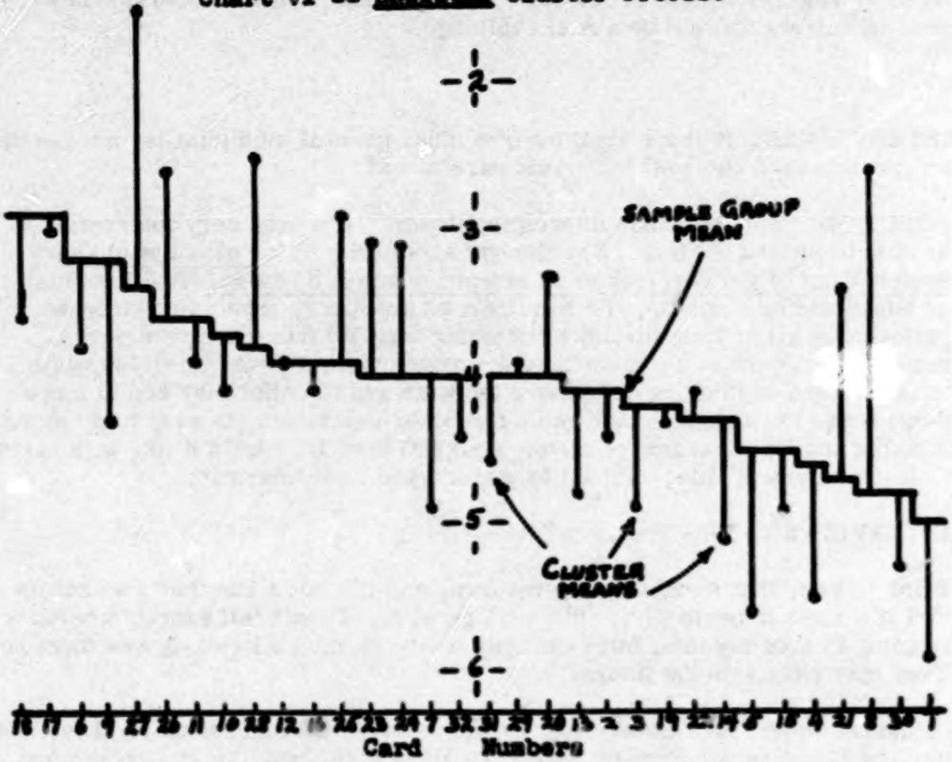
BOND: Yes, that's right. Like my own, and it's not a life that's so set up that it's rigid to begin with. It's very general. I can't tell exactly what fate is going to take me into, but I can only define things as I clearly see them now. They may change in the future.

As a human being, Mr. Bond is pretty impressive, but as a member of the control group, he is not very representative. To all effects, both the *Adolescent* and its satellite group are composed exclusively of youngsters who have abandoned science or engineering.

The cards the *Adolescent* cluster reject, as might be expected, are the money and status cards, #1 through #5 and #8.

(C) Societal Cluster

Chart VI -- Societal Cluster Profile



Mr. Bond, with his interest in service and in having an impact on the society in which he lives, and his willingness to function within a group like WHO, illustrates rather clearly the characteristics of the cluster which is a satellite of the Adolescent cluster. This ancillary cluster, which we call the Societal cluster, has eight members.

The Societal differs from the Adolescent cluster in several curious ways. Except for Mr. Bond, and a gentle, morose, ex-Marine who is also an ex-geology student, both from Ohio State, all were Stanford students. There are a few notable contrasts in card placements. The Societal is even more insistent than the Adolescent cluster that science is not enough; half its members pick card #27 as their first choice, and the other half all include it among their three second choices. Card #21, which describes scientists as too stiff to know how to enjoy themselves, is rejected by most subjects, including several of the Adolescent cluster. But the Societal feels this to be important advice.

Card #8, however, makes this contrast much more strikingly. This card, quoted above (page 44) says that scientists have too few interests to live like other upper-middle class people and lead dreary lives. It is generally rejected. But nobody in the Societal rejects it; one places it first and three others place it among their second choices. The boy who places it first, Mr. Swanson, does so with calm dogmatism from the very outset.

> **INTERVIEWER: Are there any issues that you'd want to deal with that there aren't any cards for?**

> **SWANSON:** I believe the cards covered the two main points; one, that your relations with other people are kind of stilted and that your thinking is too inner-directed, that you're not interested in arts and music, other fields besides science.
>
> **INTERVIEWER:** And your choice as the most important card, card #8, seems to be related to that. Do you have any further comment?
>
> **SWANSON:** Right. They tend to have fewer interests outside their work.

In response to the Interviewer's concluding probe, "Is there anything else you'd card to add?" Mr. Swanson states:

> **SWANSON:** I am glad, right, that people are doing research on this. ... It's good that people are looking into this because there is so much talk, and, I think, to some degree, pressure in high schools that they need scientists. Well, some people aren't cut out to be scientists and there should be nothing wrong with changing one's opinion about it at all. I'm glad to see this being done.

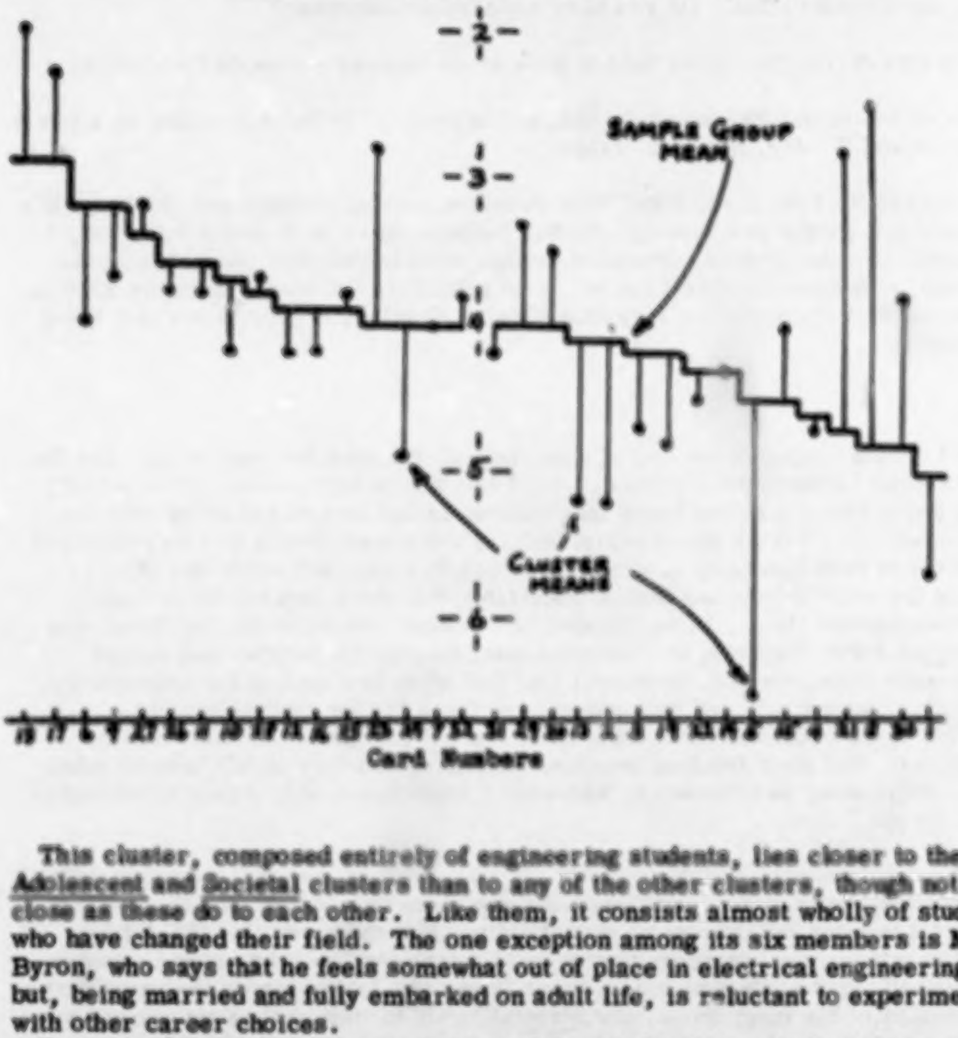
....

> I couldn't imagine looking at equations all the time for four years, and the personal element wasn't there. And I felt that in this world, we've seemed to solve every problem since man existed except how to get along with one another. ... I think the scientist and any individual should feel an obligation to try to help humanity in some way, *personal* way; and I felt that physics and the various courses that develop from that were just too stereotyped. They weren't lib ... I like the idea of a liberal education for one thing; and I'm glad that Stanford, for its scientists, has the humanities and social science requirements, because I feel that when you sign up for engineering, you're signing yourself up for a narrow track for the rest of your life. ... They think too much about their work and not enough about other outside affairs, that their thinking becomes channeled and they aren't broadminded. ...Right now, in economics, whatever I study has a very direct relationship to people.

These comments, and those of Mr. Bond just cited, suggest that an ambiguity in the cards may make the difference between the *Adolescent* cluster and the *Societal* greater than shows up statistically. For the cards that the *Adolescent* tend to interpret as warnings that scientific training, as it has become institutionalized, may stifle a student's inner flame and deafen him to the unverifiable comments of his inner voice, the *Societal* tends to interpret as warnings against ignoring matters of *personal* concern in their *external* lives. The *Adolescent* members can thus take card #27's reference to the possibility that "the questions science can answer are no longer the questions he must ask" as an allusion to deeper subjective interests; while members of the *Societal* are reminded of the broader social and political commitments that they might have made. Mr. Bond, a member of both, illustrates rather clearly the relationship between these clusters by treating both issues explicitly.

(D) The Cool Cluster

Chart VII -- Cool Cluster Profile



Card Numbers

This cluster, composed entirely of engineering students, lies closer to the Adolescent and Societal clusters than to any of the other clusters, though not so close as these do to each other. Like them, it consists almost wholly of students who have changed their field. The one exception among its six members is Mr. Byron, who says that he feels somewhat out of place in electrical engineering, but, being married and fully embarked on adult life, is reluctant to experiment with other career choices.

Because of his vivid self-expression and despite his being, in fact, a member of our control group, Mr. Byron's comments give a clearer idea than anyone else of what this cluster is like. We will call it the Cool cluster. Half of its members are from Ohio State and half are from Stanford; the quiet, ironical detachment that Mr. Byron illustrates so engagingly is rare at Brooklyn College. The card choices that distinguish the cluster are, positively, #8, #18, #21, and #23; negatively, #1, #2, #5 (which half the members of the cluster pick as worst card and the other three place in pile six) and #13. The cluster is also unusual in the consistency with which it treats the generally popular #6 ("bureaucratic life") and the unpopular #30 (science versus religion) as trivial by leaving them in or near pile four.

Except for #13, all these cards have been quoted earlier: #1 and #2 are "money" cards; #5 is the "mad scientist;" #8 says scientists lead dreary lives; and #18 warns that scientific work is carried out on an assembly line basis. Twenty-one and #23 describe scientists as stiff and narrowminded and scientific training as tending to discourage independence of thought. All this sounds like the *Adolescent* and *Societal* clusters, but it adds up to a more sweeping rejection of engineering as a way of life, while insisting that scientists are respected and generously rewarded. Notably absent is any particular stress on the "subjective judgment" cards #26 and #27, which both the *Adolescent* and the *Societal* stressed as important; the *Cool* cluster treats these in a way that does not differ statistically from the total group of subjects.

The rejected card #13 reads:

> #13. Not many scientists can dare to lead a normal political life when they know that their career may be seriously set back, no matter how competent they are, if they are charged with being a "security risk."

Mr. Hamilton, a Stanford ex-engineer now in architecture, who is the one subject who falls in both the *Cool* and *Societal* clusters demonstrates his cool side superbly in his comment on #13, his choice as worst card:

> HAMILTON: Again, perhaps, as a result of my impression as a scientist -- as far as the person whose primary goals, whose primary interests are in the field of science, who essentially attempts as much as possible to isolate himself and his work from the red tape of getting funds, getting through all this political interest and so forth, is a very dedicated man. This, in science, would seem relatively unimportant, whereas for -- as the artist or the writer, his method of communication is through his works and these are the type of values that he is communicating about and he is making judgments upon. This is, in many cases, the essence of his work, whereas it is not, it seems to me, the primary goal of the scientist.

The *Cool* cluster shares most of the *Adolescent* and *Societal* clusters, but expresses them with greater detachment. It does not identify any longer with the engineering role, as Mr. Hughes, for example, still does. It is *degage*. In a youth as piercingly bright and intellectually lithe as Mr. Byron, *degagement* may be engaging; less privileged members of the cluster sometimes seem merely querulous or petulent. Mr. Cimarosa, an Ohio State student who has gone into the School of Commerce, comments on card #21:

> CIMAROSA: I live in a fraternity house, and there's engineers -- well, the fraternity brothers of mine, it seems that whenever we get into a discussion, they're so narrow in their concepts that they're not aware of all the other factors that take place in deciding on what one thing will happen, whether it will happen this way or that way. All they can see is the scientific way and, I don't know, the systematical approach and everything, and they seem to be so narrow-minded, because they haven't been exposed to, I don't know, I guess a broader type of course in sociology or . . . they're not worried about learning how to meet people, and they're not worried about, I don't know, just the fact that they have to sell themselves to other people in order to be successful; all they're worried about is just engineering, that's all. They're just in a small course, I think. I guess the engineers are in a shell and away from the rest of the people. . . . I really am kind of prejudiced against, I mean, in my feelings against engineering. I really disliked it when I was in those two quarters. It just seemed that when I got out of engineering and got into something else, it seemed like I was more civilized or something. It's kind of a hard thing to explain, but I really -- I feel strongly about the way I do -- it's just -- I don't know; I feel strongly, but I can't explain myself. I see so many people over that stayed in that are unhappy with it, and I know so many that are unsuccessful their first year, and they get out. It's a discouraging thing. . . . If

> I'd stayed in another quarter, I'd probably have dropped out of college, because I was getting so discouraged.

Yet, Mr. Cimarosa, in responding to #5, is highly respectful:

> **CIMAROSA:** Well, I think in my estimation and in the estimation of the general public, that a scientist is held in high esteem. I mean, a person who is a scientist is very, you might say, different, because he's someone to be respected because the possibilities of intellectual potential. I don't think that he's looked down upon, looked upon as weird in the sense of "mad scientist." I think people respect scientists -- uh, engineers. I think too many people try to be engineers because of the respect that is held for them instead of what they want. I find that so many times in men that are maybe three, four years in the engineering courses, and they're sorry they're in it now, because the type of work; they're just taking courses in it. They're really not interested in it, but they're too far in it to turn back and so something else .... I mean, I respect anyone that goes through engineering college, and I respect any scientist because, actually he has so much more over me, because he's capable of looking at these problems and getting interested in solving them; but I wouldn't want to do it myself.

Most of the *Cool* cluster rejects #5 because they feel that the "mad scientist" stereotype is obsolete and not -- like Mr. Byron -- because they are not to be influenced by "the man in the street." Mr. Thwaite, a Stanford student technically classified as a physics major, but who had actually been training to become an engineer and had even worked two summers as an engineering technician in an aircraft factory, makes a similar statement from his present position as a student of linguistics. But he gets a trace of irony into it:

> **THWAITE:** This is a rather outdated legend. I think created by cartoons, comic books, this kind of thing. I think a great evidence for the fact that the layman does not have in his mind a stereotype of a mad scientist is the fact that most laymen are perfectly happy -- in fact, inspired -- by the fact that their child may want to go to college and become an engineer. And also, in the light of the public's reaction to the launching of the Sputnik, people writing letters to newspapers saying: "Why don't we have more science in high schools?" I don't think there's a stereotype of a mad scientist that's alive anymore. That's awfully misleading; more than misleading, it's nonsense.

Mr. Thwaite, too, pays his respects to his former discipline:

> **THWAITE:** In all that I've said, I've displayed a preference toward problems which one will encounter in the humanities, and a preference toward spending my life in dealing with those problems, particularly within my own field. ... Now, I don't at all regret the interest that I have had, and the smaller interest that I now do have in science, particularly in the scientific method. Because I would not deny -- in fact, I'd be the last to deny it, that the scientific method is a good discipline to which one should subordinate one's mind and one's thinking process. It's a good approach to things. Scientific method, in itself, is not, or does not hamper thinking about questions of a humanistic nature. And so, I would not discourage anyone from taking a small selective program in mathematics, logic, or physics, for that matter. You get much more of an understanding of what is going on in the world about you.

But Mr. Thwaite saw little possibility that the realities of professional life would have permitted him to indulge his interest in science on this level:

> THWAITE: Now when I say the word "scientist," I think of somebody who's an engineer or an aerodynamicist in a defense corporation or something like that; because, as I said, I think there's rather a minority of people who remain in the rather stimulating atmosphere of the university. The average scientist, if he was at all interested in humanistic ideas and questions, would not find the time if he goes into work with a corporation or industry, to follow this up, and will soon find himself losing interest in this. Now, if I went into this sort of career, I would probably lose interest in this type of thing too, although not completely. I would hate to do that; I would rather retain that interest and sacrifice a career in the sciences. I'm not saying that science completely stifles this type of thing. It just seems to be the general case. It seems to be a phenomenon which you can observe almost anywhere.

Mr. Gundig has observed it at Ohio State, though he is a bit more earthy in describing it:

> GUNDIG: Well, from what I've heard and what I've seen around different places, I feel that ... well, actually, they seem to just ... most of them ... lower scientists seem to just have been like sort of ants. Some places I've visited and toured to they just ... they don't seem to know what they're doing. They're just told to do a certain task. They don't know the overall purpose of it. Myself, I just like to know what's going on.

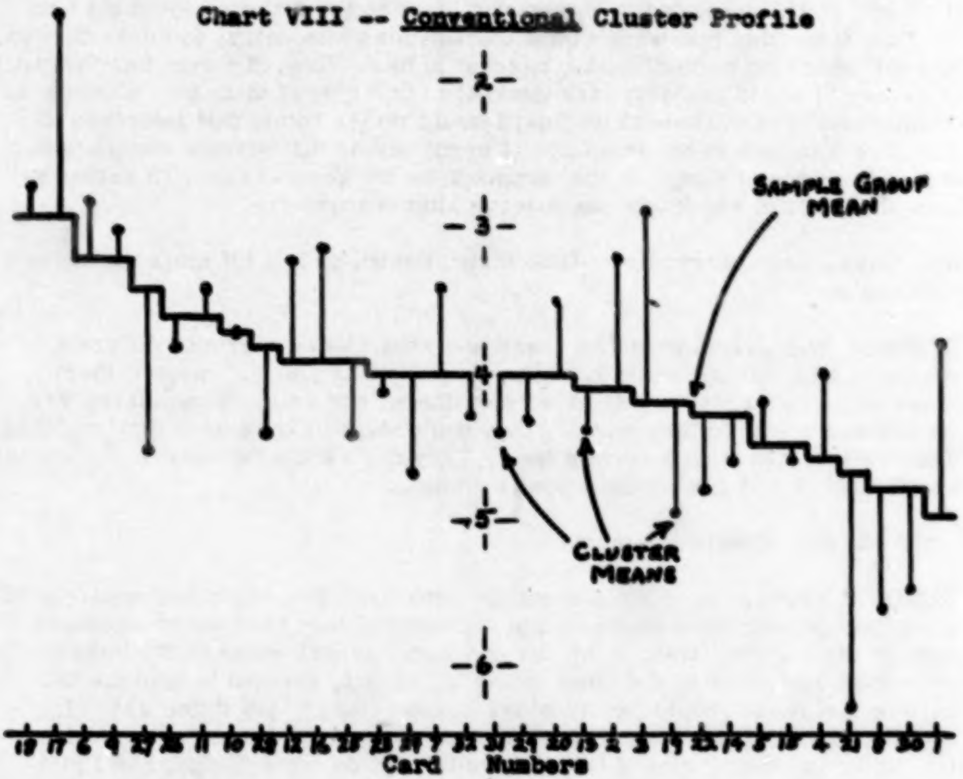
Of card #8, Mr. Gundig comments:

> GUNDIG: This card concerns scientists who don't live like other upper-middle class people even when they're quite successful, they have fewer interests outside their work. Well, I felt that my contacts with some of the instructors over there and some of the other students, in fact, seemed to lead me to believe that these people just lived for engineering, to put it one way. I, myself, am not that strong on the subject. I mean, it interests me, but I like other interests, too. I like to have time to do other things, and I just couldn't find the time for other things at that time. And it looked like it was going to be ... from what I'd seen ... it was going to be that way all the time. ... I feel over here in Commerce, the people have much broader outlooks. Not just to live for one thing only. They like to do other things, too.

Clearly the Cool cluster is a consequence of the way basic engineering courses are taught in this country, as well as of what its members have in common. If any one of them had started out in pure science rather than in engineering, it is unlikely that he would have chosen cards that put him in this cluster, since comments specific to the engineering experience pervade the interviews. Speculating at a more fundamental level yet, it is not unlikely that the basic detachment and inattention to the inner life that distinguish the Cool cluster from the Adolescent and the Societal were also expressed in the selection of the more concrete career pattern. Yet, though the members of the Cool cluster have adopted a posture of uninvolvement, their comments add up to a sharp body of social criticism, which is quite perceptive enough to demonstrate their awareness of, and basic concern about, the social realities that led them to question their career choices.

(E) The Conventional Cluster

Chart VIII -- Conventional Cluster Profile



The Eclectic cluster also has an ancillary cluster of eleven subjects, who bear about the same relationship to it as the Societal does to the Adolescent cluster. Three members overlap -- a smaller proportion in this case -- and the cluster represents an exaggeration of some of the characteristics of the Eclectic cluster in a comparable way. This cluster also includes former science students or engineers and controls. Its members are drawn from all three schools.

What is exaggerated here is the conventionality of the Eclectic cluster. The controls seem almost to parody conventionality in their acceptance of their world and their reduction of every fundamental conflict to the most stereotyped terms. Two of these, however, are recent arrivals from northern Europe, one of whom is returning to Norway as soon as he has finished his degree. These two control group members have, in reality, less reason to be concerned with subtler aspects of the American way of life. The students who have abandoned science seem to have failed to establish their identity. It is impossible to quote excerpts from their interviews that give a vivid picture of what kind of persons they are, for no such picture became established.

These qualities show up in the cards by the subjects' slight tendency to accept card #1, "Scientists make too little money ..." as sound advice, while most other subjects reject it; and by their tendency to reject as nonsensical the cards that emphasize the conflict between science and subjective aspects of experience. They emphasize even more than the Eclectic cluster that science is fill of "dull, routine activity" -- Mr. Rabinow is one of the overlapping members -- but generally, if controls, in the context that this is okay as long as you expect it. The experimentals complain about this dullness, but seem to have nothing brighter to suggest in its place. Like the Eclectics, the Conventionals insist that scientists have just as much fun as anybody. The way that Mr. Jones -- an Ohio State engineering control -- refers to this fun has taken on an unanticipated quality of nostalgia since his interview a year ago:

> JONES: They're people, scientists are people, educated people. Enjoy getting together, enjoy parties. I don't think I could exist without my golf in the summertime.

While a Brooklyn College lad, who sums up his reasons for leaving engineering simply by saying: "Well, I didn't find it exciting; I found it boring," recalls one of his former science colleagues:

> SUBJECT: Many of my friends are engineers or pure scientists or mathematicians and I find that they tend to like music, art; they believe very well in girls -- and outside of working hours they're ... you couldn't stereotype them as scientists at all.

Mr. Jones defends his choice of card #2:

> JONES: Well, this is a personal gripe here. Everyone wants more money. I have no real torch to carry here, and say we deserve a bigger share of the pot; it's just that I want a bigger share.

While of card #6, the "modern, bureaucratic life," card, which Mr. Jones regards as important, he says:

> JONES: Well, this is the fact of life in industry. I have no quarrel with this, but anyone who contemplates going into a career, in science should, I feel, know that they're not going to be the boss. They're going to be the department. The managers are going to be the bosses if they're in industry. ... I think it's a happy association.

In her comment on card #25 -- the scientific method, as taught ... hampers efforts to understand -- Miss Larinn, an attractive and very bright young chemist, who is one of the European subjects in the Conventional cluster, clearly illustrates the sometimes illogical positivism of this group:

> LARINN: Well, well, science doesn't deal with philosophical understanding of problems. It's true that you cannot gain a philosophical understanding of the problem through the scientific method. On the other hand, I think it's impossible to solve any scientific problem through a philosophical approach. I think that -- the statement on this card is just a complete misconception of the way that scientific method is applied and so forth.

Mr. Rabinow sputters away like a chunk of sodium in a hot shower when he expatiates on his choice of card #30 -- the conflict of science and religion -- as the most misleading card:

> RABINOW: Oh well, I don't, I didn't say that, I don't think, if I did I'll take it back. I don't -- to me, I don't see why people place science and religion on just, you know, why they want to always compare them and why they want to say one is trying to disprove the other. I mean, one is -- I don't believe the essential purpose of religion is salvation, you know. ... I believe the more essential purpose of religion is more or less to have people, well, I wouldn't

say -- morally correlated, you know, getting along well with each other, et cetera, and have a high ethical, moral standard; and the purpose of science is to understand the physical and phenomenon of the world, and, to me, the story of creation, so if science says a (word lost) however, was from a cosmic explosion, whatever they want to say was created -- all the different views, to me it doesn't even conflict with religion, because after all, it depends on what you want to believe in religion.

While Miss Pearl, a Brooklyn College biology major who has changed to elementary school teaching, also disparages the unverifiable in rejecting the generally popular card #27, which the Conventional cluster picks as misleading:

PEARL: Well, I think that a person never gets too fa, to feel that the questions he has to ask are the ones that science can't answer because I feel that even if science cannot answer them now, science might be able to answer them later on, in the future, the same way people once asked what caused disease and they said it was devils, and now we know that they're caused by bacteria and viruses and many other things.

Mr. Sansome, a Stanford economics major, who says of his change in career plans:

SANSOME: I was taking engineering because it was a very practical field to be in, and I got out of engineering because that kind of work didn't agree with me, and I really haven't been able to pin it down as to why it didn't agree with me. I was hoping that this study would help me get some ideas.

rejects card #27 even more forthrightly:

SANSOME: I think this is mostly hogwash as far as I am concerned. ... I think that the empirical method will make a lot of things that are now important to people in philosophy ... make dead issues out of an awful lot of things, because they're -- instead of being able to pick your assumptions, you're going to be limited to a few assumptions that apply; where now the lot is conjecture, there'll be empirical bases for conclusions later on, and that's going to limit such fields as philosophy quite a bit, and religion. It's going to be a little bit rough on these people.

The distinct character of the Conventional cluster seems to be its inability to imagine any real alternative to the values and assumptions it is accustomed to. They defend science and scientists, though some have left the field in response to various comparatively disorganized feelings of personal dissatisfaction with the way science works today. Others are going ahead as planned.

(F) The Old Pros

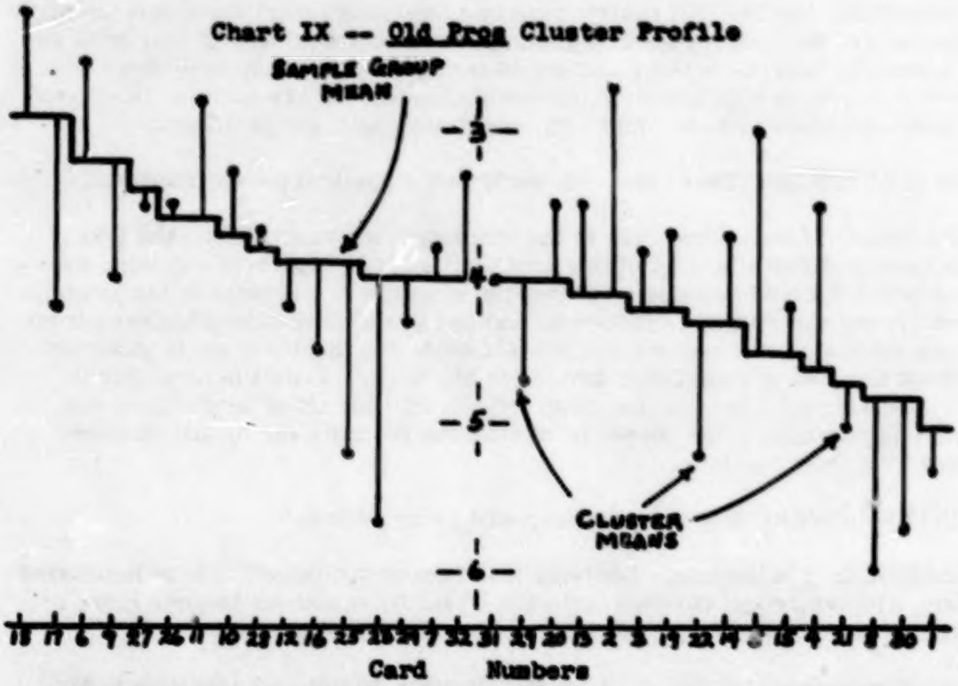


Chart IX -- Old Pros Cluster Profile

We have no cluster of brilliant, creative youngsters who expect to fulfill their destiny and their inner vision within science; but we do have a small, five-man cluster composed entirely of highly successful, continuing Ohio State science and engineering students.* The quality of their response is illustrated by the comments of Mr. Wheeler, whom we have already quoted in Chapter V, p. 53. Another member of this cluster, Mr. Patrick has this to say in explaining his card-choices:

> **INTERVIEWER:** Then, turning to your actual card-choices, the card that you selected as the most important piece of advice was card #2. Would you care to comment on your reasons for picking that?
>
> **PATRICK:** Well first, I would like to say that I didn't find any of the cards very valid reasons in my opinion. I just picked the most valid.
>
> **INTERVIEWER:** Why is that, incidentally, is it that you feel, then, that there really are very few drawbacks to an engineering career or what?
>
> **PATRICK:** Yes sir, outside of the time it takes and the perseverance it takes to put into it. I think so. I picked the card on salaries mainly because I feel that it's somewhat true. It opposes itself to doctors and lawyers here specifically, and certainly as a doctor or lawyer you have a chance to go farther faster. As a scientist, certainly you can make as good a salary, but it does take longer in my opinion, and it takes a little more individual ... in the light of individual accomplishments. And I believe that you're not going to get rich quick as an engineer. You're going to make a good salary. I believe, if you're a good engineer, but you're not going to get rich quick

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* Actually, this cluster has six members. For the reason we have removed one member from the cluster cf. p.35, above.

like doctors and lawyers.

INTERVIEWER: How important do you think generally this is to engineers?

PATRICK: Not too, not really important, because I don't think that too many people are that interested in becoming so terribly wealthy. If they have an inclination towards science and engineering, they probably have some sort of more or less devotion to duty, possibly, and wouldn't be quite so interested in the monetary values. Although, like I say, he'll get paid well.

INTERVIEWER: Then, the next cards in the positive group, card #5?

PATRICK: This is referring to the stereotype mad scientist. And I do believe that there is a lot of this idea still existing in people's minds, possibly not the mad scientist, but that the scientist or engineer is the fellow who keeps the midnight oil burning and has practically ruined his eyes from intense study and research and doesn't know that there's a world going on about him and is completely devoted to his work. I don't believe this is true at all, but I believe this is an attitude that too many people have and this discourages some people from entering the engineering and science and also their opinions.

INTERVIEWER: It is fairly widespread as an attitude?

PATRICK: I believe so. I believe it is improving; the attitude is improving now with the recent developments and so forth, scientists become more to the forefront. But I still believe a lot of people feel this way.

Another member of this cluster, Mr. Brandt, begins in a like vein to Mr. Patrick:

INTERVIEWER: First, if you were considering giving advice simply yourself to a person about to start out in science, and wanted to point out what some of the difficulties or drawbacks might be, are there issues not touched on by these cards that you would want to deal with?

BRANDT: No, I think the ... major questions involved are first of all the question of what the public thinks of the scientist, the question of money, and the question of what the sciences really are, and I think the cards contain these three things.

INTERVIEWER: Then turning to the cards that you actually selected, your choice for the one most important card was card #5. Would you care to comment on your reasons for picking that card?

BRANDT: Well, that is simply a card related to one of those three questions. Mainly, the attitude of the public. Actually, I was much more concerned with the negative cards at the bottom. The many more that deal with the same subject. It was a little harder to pick the ones that I agreed with and the top one simply happens to represent the view of the public, the closest that I could discover.

In its card-choices and comments, this little cluster treats science as would a group of comfortable "old pros." They see card #17 -- dull, routine -- simply as trivial, leaving it in the middle of the distribution; and like most of the controls, they vigorously reject #23 and #25. But they never seem defensive in the quality of their responses. Compare this subject's treatment of card #30 which this cluster consistently rejects, with that of the Conventional Mr. Rabinow, already quoted:

> SUBJECT: This is the question of science versus religion. I do not feel that science is against religion or religion is against science. I feel that they are perfectly compatible. There are questions which I don't know if science will ever be able to answer, but in my own estimation, I see no place where science actually contradicts anything in our religion; in the Christian religion, shall I say. And I believe that more and more -- I think that the scientist and the theologians are coming closer together in their attitudes in working together, and I think that in the future this controversy will die out.

To the "Old Pros" both science and religion are against sin and ignorance, and therefore, are bound to triumph; they are quite intelligent enough to be able to agree afterwards on a satisfactory division of their proper spheres of influence.

Both card #18 -- assembly line -- and #6 -- line pulls more than staff -- are popular with the Old Pros. And they like to discuss these cards in terms of concrete experience, too. Miss Sharpe, for one, comments as follows:

> MISS SHARPE: I selected card #18 because I've had a summer job in industry last summer, and I despised it very much, because I was one of those people on the assembly line, and I wasn't supposed to have that kind of a job.
>
> INTERVIEWER: You mean you had been promised a different sort, or ...?
>
> MISS SHARPE: Well, I thought that I was having a job that would test my ability. Instead, I had a job which I feel that anybody could have done. You could say a technician of a sort. Anybody who had brains to wash dishes. ... We did analytical work at ______ Company. They had a select group of people and they gave them terrible jobs, so nobody wanted to go back. If they had given us a harder job or more difficult, more people would have wanted to come back.
>
> INTERVIEWER: Then card #6 would appear to be somewhat related to that, really?
>
> MISS SHARPE: Yes. It's the only reason to be my summer work that I chose this card #6. Probably that includes all my decisions, because before then I had, well, I like chemistry, and I didn't find any reasons why I shouldn't go into it. I don't like to be -- I'm a, well, do work that you can do without a college education.

While Mr. Wheeler is again pleasantly forthright:

> WHEELER: Well, I wonder if I might modify this card #6 just slightly. I think it says that the bureaucratic life-line always pulls more weight. I don't believe that it always does, but I believe, in general, that administrative policy will tend to push down a lot of scientific work if, oh, management or somebody else finds that there's a reason for putting it down, although the scientist doesn't himself feel that there's a reason to depress the work. I think that's my main reason for choosing it. I did work in industry last summer and saw a little bit of this just in one summer's work.
>
> INTERVIEWER: How does it affect your future plans, if at all?

WHEELER: Well, myself, not too much. I believe that scientists, on the whole ... uh, well, they do, they can pull their own weight as far as their decisions when they get to a high enough position that their decisions are respected and I hope someday to get to a high position in science, although I believe that it's the lower men, engineers, some of the people might even call technicians whose decisions a lot of times are not too well respected.

INTERVIEWER: And do you suppose this is a thing that is within one's own control to any extent, or is it a matter of natural endowments that you can't do much about?

WHEELER: Well, I think the whole public needs a little more education as far as ... regarding the decisions that scientists make ... a little more trust towards scientists and not being quite so slow in many ways to accept the new ... new plans or decisions that come from the scientist.

INTERVIEWER: But that may not in itself, of course, provide much more autonomy within an administrative organization.

WHEELER: That's true.

....

INTERVIEWER: And finally your final positive card, card #18, which is, after all quite related, Mr. Wheeler, to this topic.

WHEELER: Okay, fine. Again, my experience this summer working; I worked for a fairly large industry and there were many, well, many of the men that worked there who had engineering degrees, actually again, unless they were outstanding, they were, as it says here, hammering away at a particular part of the job and actually a lot of times didn't know the total picture or if they did know the total picture, weren't in a position where they could do too much about it. And, as I say, unless they were outstanding, they didn't stand too much of a chance for a promotion.

Mr. Wheeler was interviewed together with another control group member. The latter, who is not a member of the Old Pro cluster, chose card #9 -- scientists don't participate in decision making -- for his second pile. Wheeler, who had placed #9 in pile five, began to reconsider:

WHEELER: I see by placing this one in slightly negative, I've contradicted myself a little bit, although possibly I think I had reasons for choosing it the way I did.

INTERVIEWER: Yes, what were they?

WHEELER: Well, I said before that part of a scientist's work is rather controlled by bureaucracy, you might say, and here it states that scientists don't get much chance to participate in making the decisions that govern their work. Well, I disagree on that, too, although they may have their work repressed at times. I believe that they do have quite a bit to say on general policy concerning their work. I might use as one example, the military when it comes to developing new weapons or something like that. It's the scientists who determine, for the most part, I think, what we're going to have and how it's going to be used.

INTERVIEWER: Then, as I understand it, the reason for your distinction really is that you are distinguishing between the consequences of the scientist's indispensable technique and knowledge which, in any case, will have an impact and his actual formal participation in policy-making decisions.

WHEELER: I believe so, yes. I think the scientist must be prepared to have part of his work repressed by management or someone else who doesn't care for what he's doing.

INTERVIEWER: Then what is the nature of such preparation?

WHEELER: I think resignation is probably the best thing.

The Old Pros are nice guys (one of them is a nice girl) and no sweat. They are committed, though not dedicated, to science or engineering and they will make good, solid contributions that will get bigger and better as they learn their way around. They are conventional -- their cluster lies closer to the Conventional cluster than to any other -- in their own way, but they are not twitchy. They'll do just fine. In the idiom of fifty years ago, one might have said of them that they would never set the world on fire. Today, well, these are the kind of competent young men and women who get their job done.*

The Old Pros are more mature and better adjusted than the Adolescent. But it seems to us that this means merely that as late adolescents continue to grow up in the United States they find life easier, and are granted more opportunities with fewer conflicts, if the Old Pro values are the ones that come naturally to them. They are more mature in the sense that they are more like successful adults and therefore less threatening. But they are not more mature in the sense of being more nearly ready to bear the rich harvest of which the human species, under favorable conditions, is capable.

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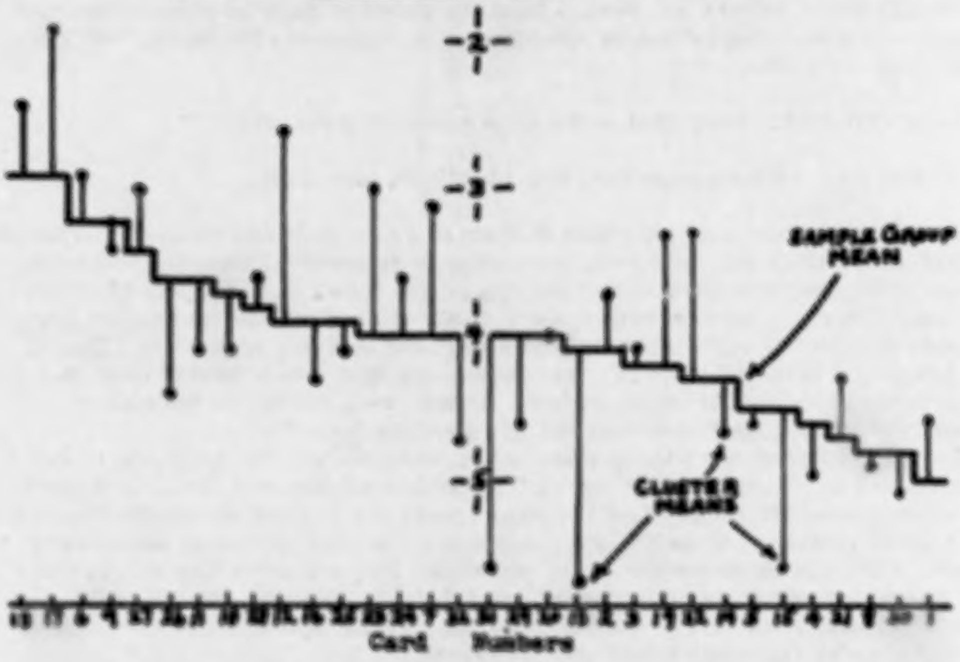
* Sir Charles Snow's Minister of Production, Thomas Bevill, is a little blunter about them. "It's funny about those chaps," he reflected, "I used to think scientists were supermen. But they're not supermen, are they? Some of them are brilliant, I grant you that. But between you and me, Eliot, a good many of them are like garage hands. Those are the chaps who are going to blow us all up." The New Men, pp. 67-68, New York, Charles Scribner's Sons, The Scribner Library, 1954.

(G) The Anti-Ideological Cluster

Chart X -- Anti-Ideological Cluster Profile



Our method of analyzing the data yields two further clusters, both clean. Their members do not overlap into any other clusters and both include subjects who have abandoned scientific training and subjects who are continuing in it. The larger of these we call the Anti-Ideological cluster.

This seven man cluster, to which all three colleges contribute, is defined primarily by its specifically anti-ideological quality. Topologically closer to the Conventional cluster than to any other, it is still at some distance removed from it.

The cluster is task-oriented in its attitude toward science, and uncritical to the point of blindness of the social context in which science functions. Ironically, this makes it the only cluster in the formation of which the political cards play much of a part. Both card #12 -- the "security risk" card and card #15, which reads:

> #15. There is not much room in science today for the true conservative. The climate of opinion is such that an individual who shared the American people's recognition of the need for vigilance imposed by the Cold War would be given a pretty hard time by his colleagues.

are very strongly rejected by members of this cluster. Thirteen is generally treated as neutral or trivial by the subjects in the study, while fifteen tends to be somewhat rejected by them --but not nearly so strongly as by the members of the Anti-Ideological cluster.

Ideologically, these two cards express ideas representative of roughly opposite political orientation; so that the fact that both are about equally unpopular with the cluster explains the title we have given it; ideology itself strikes them as an unnecessary and irritating obstruction to the conduct of practical affairs. They express this attitude in comments such as:

> **MR. BEZANT OF OHIO STATE:** I think this statement (#13, his 7th or most negative card) is kind of ridiculous. I think anybody in this country is -- leads whatever political life they want to without fear, and that's the basis I chose this on; this is a ridiculous statement. ... (on related #16) The scientist hasn't really lost any of his securities by shifting from the university centers to the government, which quite a few scientists are doing now. I believe that it gives them more freedom, and gives them more resources in order to practice what they believe, to continue on their work. So this was another less ridiculous statement, and yet still is.

> **JETHRO:** (commenting on #13 and #15 together) Well, here I consider two extremely trivial reasons why you cannot be a scientist. In the first place, science and politics are not so interrelated that you cannot become a scientist regardless of what your political views are; and when it says that there -- you cannot be a conservative and be a scientist -- to me, this simply is not true. There have been many radical people in science -- that you're labeled as being radical or something -- I think this is completely untrue. I think the field of science itself is for people that are dedicated to research, that are interested in using their minds in this way and I don't see how politics enters into it at all.

This young Stanford student, who has changed from biology to economics, does not himself share what he describes as dedication to research. In response to the Interviewer's conventional probe for "a general, overall reason for your change," he said:

> **JETHRO:** Well, I changed just a year ago to day, after I'd been in biology a full year, having taken a full year of chemistry and a full year of biology, including organic chemistry. I guess the main reason is that I finally reached the point of satiation; in other words, I got to the point ... one day I was in the biological lab. I was working at the Ascaris, which is an intestinal worm of a horse. I was staring at it, and I was just wondering, "What is the purpose of all this? Why is it that I have to spend my entire time filling my mind with detailed knowledge of events of this nature?" It seemed to me that my mind was capable, perhaps, of some reasoning, you see.

A viewpoint both harsher and less consistent is expressed by an Ohio State control group member, Mr. Hyde, who is making an excellent record in electrical engineering.

> **HYDE:** Well, #13 was "political life" and it says that not many scientists dare lead a normal political life. Now, when I think of a normal political life, I think, "he votes." Now, maybe you had reference in going out and doing a little stumping on his own, running for office or things like this. Perhaps he does, maybe he feels restricted in this way, but I don't think that because he's a scientist, which I don't know what the meaning of that is, that they shouldn't restrict his political life anyway. I mean, it's definitely if he thinks that communism is the best, he's not going to make out too well in U.S. Government labs, but he'll do quite well in Russia, so he's not too much restricted there. They'll be glad to get rid of him, too, from what I hear.

> **INTERVIEWER:** Which implies that he would then be permitted to go to Russia?

HYDE: Oh well, when I said they'd be glad to get rid of him, I say that they wouldn't want him around, whether or not the policy is such that he could make the change. This, I don't know, but he definitely would be out of there before long.

....

(on #15) I don't think because you, if you recognize the need for vigilance, you're going to be given a hard time by your colleagues, because you're being paid because of that need for vigilance in many cases. ... You work at Huntsville, Alabama, making missiles or something like that, and there's quite a bit of money in that; so if you don't recognize the need for vigilance chances are you won't think your job is too important and you'll go work somewhere else or something like that.

The disparaging, anti-intraceptive quality in the feeling tone of the members of the Anti-Ideological cluster is curiously revealed in a slightly earlier comment of this subject in explaining his rejection of #26, which is mildly unpopular with the cluster. Number 26 is the card that begins: "The scientist's commitment to place objectivity first ... ultimately limits his power to penetrate to fundamental meanings." This young engineering student said:

HYDE: I feel as though experience of any kind sort of prepares you for future experiences; opens up your potential. ... I should think, I do think, that as you go along, anything that you do gives you some background to tackle anything new. I mean, if I carried garbage for ten years, I'd feel competent in that field; and if someone asked me to carry trash, I'd say: "Sure, I carry garbage, and I can switch over and carry trash for a while." And I could become a truck driver after a while. I mean, that's the way I look at the thing. So merely if a man has experience in engineering or science or something like this, if he's called upon to do something new, make decisions, probe fundamental meanings, he has the potential to probe them.

From the tenor of these comments, one would expect #31 -- truth in embarrassing commerce with Mars and Mammon -- to be very unpopular with the Anti-Ideological cluster; it ranks immediately below #13.

One student who explains his change from mathematics to political science with the simple statement: "I found that I was not interested in what I was taking at all; I wanted to get into something I was interested in," is almost as vague in stating why he picked #31 as number 7:

OHRDRUF: I thought that this one was the one that was pretty well, way out, if you know what I mean. That's a poor reason, this idea that you have to be pretty careful in order to catch Truth in embarrassing -- suggests a limitation on what you can really believe. I don't believe this is true in practice.

In his comment, Mr. Bezant is even clearer and more specific than Mr. Ohrdruf:

BEZANT: I don't think our scientists today are afraid to tell the truth no matter who they embarrass. I mean, that's what they're trained for, to tell what they believe, and what they find out through research, and I don't think that they're afraid to say what they believe, and that basically they aren't -- I think it -- subsidized by certain groups and I don't think they necessarily are even though they work for the government. They're basically free to do what they ...

INTERVIEWER: Of course, the real question here isn't about a scientist being free to say what he believes, but to investigate what he wants to investigate.

BEZANT: That's true. That's a second meaning that you can get from this. I think that now there's so many endeavors in the government that they really hit at all points. You can see that in the government right now, they're stepping on each others' toes all the time. They won't have any qualms about investigating certain things and doing research on things even though it might hurt something else.

We have begun our analysis of the Anti-Ideological cluster with their negative card choices because a kind of naive denial of what many persons would regard as simple social reality is among their most striking characteristics. Their most conspicuous positive choice is card #12, usually regarded as trivial. It reads:

> #12. Some of the satisfaction of success for a normal human being comes from being recognized as the responsible leader to whom subordinates turn for guidance. There is too little of this in the way scientific research is usually conducted today; what isn't strictly impersonal is teamwork.

This fits well with the authoritarian cast of some of the attitudes quoted; one would expect these young men to make good high scores on the F-scale, though we have no such data. Their comments, however, emphasize the more genial implications of the card.

OHRDRUF: (who placed this card first) I think I probably chose #12 because I think my interests lie more in working with people and not so much in the scientific area. And this is probably one reason why I got out of engineering. 'Cause I look at it as a field (word lost) dealing more in just working with scientific or practical applications of scientific things, and not so much of the line of working more with people, their interests, and et cetera. I'm planning to go into law school.

A few days before the interview, this subject, very much a student leader on his campus, had been unfavorably publicized in the campus daily newspaper for his position in support of an administrative ruling that the Student Council lacked the power to transmit to the Faculty Council a recommendation that landladies who refused rooms to Negro students be barred from the "approved lists" of university housing.

Mr. Jethro, who had failed to find fulfilment among the intestinal parasites of the horse, put it this way:

JETHRO: I feel that for anyone to receive satisfaction, or to achieve a high point in his life, he should have a great deal of working with people. Well, this is just personal from my standpoint; a lot of people will disagree with me. I feel that way and I felt that, in many cases -- not all certainly -- many scientists don't and they stay in their laboratory and this ... I mean, this says exactly what I mean almost, some of the success for normal human beings comes with being recognized as being responsible people -- coming to them for advice, as having a bit of authority in different fields -- that sort of thing, whereas a scientist, although people might come to him for advice, it would be on a specific thing -- in other words, kind of like a machine -- and I don't see satisfaction coming from that.

This subject cites Dr. Edward Teller, the physicist, as "a case completely contrary -- he deals with people quite a bit."

Scattered throughout the interviews, one finds among members of the cluster a determination not to look inward. One young man explains his change from engineering to commerce by asserting:

> SUBJECT:I liked the field of engineering, but I liked something else much better, and that's how I changed. That's one of the reasons why I changed. In fact, it's the only reason why I changed.

Another -- the same who fancied himself as a flexible dustman -- comments:

> HYDE: I'm jumping in on the deep end here; this deals with -- it's definitely not scientific, the meaning of life which I'm definitely not qualified to comment on, but I go along with the reasoning that's on the card. (#28)

Two paragraphs later, the Interviewer says: "I'm interested in your comment that you're definitely not qualified to speak about the meaning of life."

> HYDE: For sure.
>
> INTERVIEWER: Do you ... you will be at some time, don't you suppose?
>
> HYDE: I doubt that.

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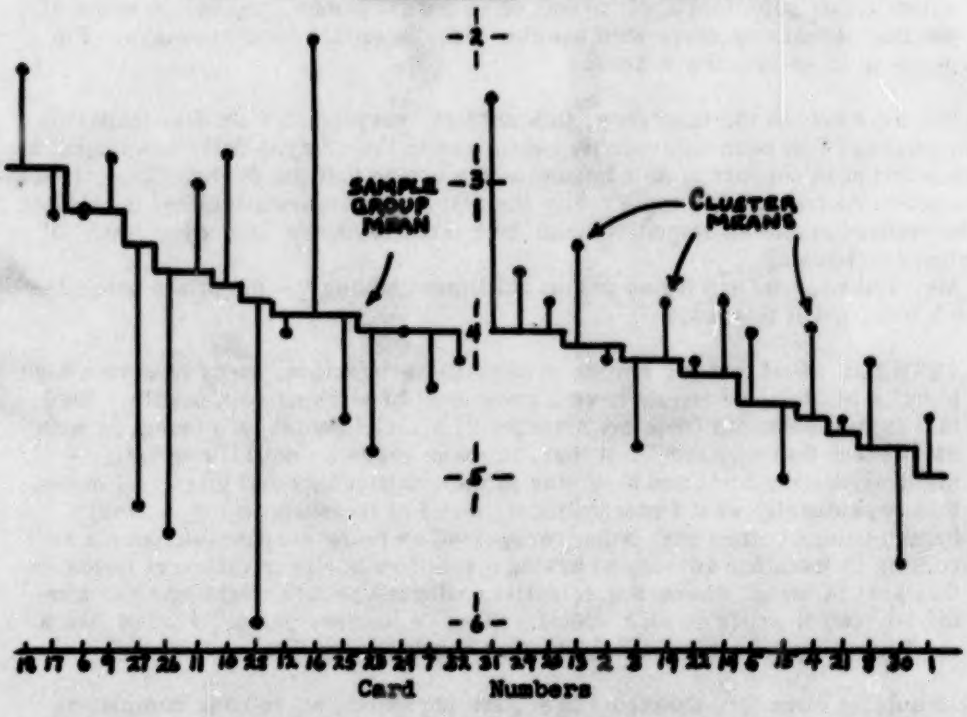
(H) The Inscrutable Cluster

Chart XI -- Inscrutable Cluster Profile



The most remote of all clusters in the study -- that is, the cluster with the largest set of sigma-D^2 values as computed between its mean card placements and those of the other clusters -- is also the most nearly inscrutable. It is clear, to be sure, which card-choices generated it, but the individuals who compose it seem to have nothing else in common. This may be simply a breakdown of the method, but if it is, it is a little surprising that the cluster should turn out to be the most extreme of all.

There are five people in the cluster: an ex-engineer from Stanford and two ex-scientists from Brooklyn; a continuing chemist from Ohio State and a continuing electrical engineer from Stanford. One of the two Brooklyn ex-scientists is a young man and the other is a young woman. It is hard to see how any greater diversity could have been encompassed among five members of our sample.

The cards that generate the cluster are, on the positive side, #16 (which all five members of the Inscrutable cluster place in pile 2) and #31, "Mars and Mammon" card (which four of the five members of the cluster place in pile 3 and one makes his first choice). Card #16 reads:

> #16. The career of the scientist has gradually become more insecure as the center of scientific activity has shifted from the university to industry and government. In industry and government, there are no such institutions as tenure and academic freedom. Even though he is, broadly speaking, an intellectual, the scientist can count on no safeguards of this kind.

The subjects' comments on #16 tell us very little; in general, they simply say that what the card says is true. Those who are continuing in science adduce this as a reason for becoming academic rather than industrial scientists. Moreover, they see very little difference between this card and #18 ("assembly line basis"); their concern, that is, is not with threats to the civil liberties of scientists, but is part of an overall objection to the fragmentation of their work. Mr. Bolivar, an excellent Ohio State chemistry student who is continuing his training with a university career in view, says:

> BOLIVAR: Well, this one here, it says you don't have so much academic freedom since science, the center of scientific activities shifted from the university to industry and government. Well, I think that's largely true. I worked for Powers Aircraft Corporation two summers and I think this criticism applies mainly to people who get only a B. S. degree. I think if you just get a B. S. degree you're not too well off. And from what I understand from one of my history instructors, it's going to be worse. As time goes along, there is going to be quite an excess of people with Bachelor's degrees in science and they just get all they can do is routine technical work, and it's not very interesting. You don't have a choice of your problem, you're working for somebody else. That's the big advantage in science, I think, is that you can work for yourself and do what you want if you stay in a university and do graduate work; but when you work for industry, you have to do what they want you to do and that's bad.

Mr. Imaji, a Stanford boy born in this country of partially Japanese ancestry, who has changed from an engineering to an architecture major, does approach the social implications of the shift in control of scientific activity to government in his comments on #31, his first choice:

> IMAJI: Well, this goes back, at least, to what I've observed, at any rate, in what scientists have done in relation to (word lost) in the general thing of society, and that they do seem to be limited in this, but they don't want to take the initiative in expressing their views -- whether they go into a project and they work on this. Now this is purely, again, something very personal with the scientist; whether he's going to allow himself to be subjected to the workings of a group or a society, and not to speak up when something he's been doing wrong -- perhaps the development of the Hydrogen Bomb and things

like this, you see. This, I think, is a failure in this. One of the major things that I think -- I -- feel strongly, not that I'd ever be a great scientist or something like that.

The negative choices of the Inscrutable cluster are highly consistent. Cards #28, #26 and #27 are their choices for the most misleading; three of the five place #28 as the one worst card, while #26 and #27 are chosen by the remaining members. All these are cards that warn against the tendency of scientific objectivity and empiricism to rule out of consideration or obscure the more significant meanings of human experience. And all are sharply rejected by the members of this cluster, whose positive choices nevertheless express their fear that the way science is institutionalized will violate their personal autonomy.

The members of the Inscrutable cluster, that is, appear to be threatened only by the way in which science is institutionalized, but not at all by the epistemological character of the scientific method itself. Mr. Bolivar, responding to Card #28, expresses very explicitly the rather extravagant view of science on which these attitudes rest:

> **BOLIVAR:** I don't know, maybe it's kind of foolish, but I just sort of have the hope or the idea that it's possible that science or something, or if not science, something, some of the outgrowths of science, is capable of solving all of human problems. In some ways, this seems kind of wrong. I might be completely wrong here, but I don't think that anybody really knows what the capabilities of science are yet. It's very new when you consider that man has been on earth a million years, the earth is two billion years old and science was just started; well, really, didn't get started at all until a couple of hundred years ago. We just have no ideas of what the potentialities of it are. And to make a rash statement that science is incapable of solving certain problems, I think it's just unwise. It might not be true at all. Perhaps science as we know it won't solve everything, but perhaps there will be outgrowths of science, later developments and new approaches that will be more fully explored and these will tend to solve certain problems. The problems that I'm concerned with are like people don't know what time is -- that's sort of a philosophical problem, and just the idea of space, like if you get in a rocket ship and travel out indefinitely into space, where is the end? See, it's just a problem; there can't be any end, but at the same time everything we know has an end. ... Well, there's a question as to whether science could ever come to terms with these problems, but I think that maybe they could. ... Well, when you say these questions, it does seem sort of absurd in a way to insist that science could solve them; but I just think that it would be advantageous for everybody just to sort of reserve their judgment. Science is going to advance a good deal in a lot of areas in the near future and perhaps as it does advance over the next hundred, few hundred or thousand years, these later developments may make these questions meaningless. Maybe when you say should we or shouldn't we have segregation or should we or shouldn't we have capital punishment, maybe these questions will turn out to be meaningless. ... I think that the idea of putting something to test, as science does, is the best way to go about it.

Of #26, Mr. Bolivar says:

> **BOLIVAR:** I think sometimes a scientist has to have insight, and you can't just go along borrowing a scientific method. Not scientific method; but you can't go along just making routine determinations of various constants and equations and expect to get anything startling. You have to have a certain amount of insight to make a new development, which is the real big contribution to science, but I don't think putting objectivity first hinders this. ...

I think science has just got to be run that way. That's the nature of science. This deal on #26 here, I think that you've got to have the objective method in science, and that's just part of science itself and that's not -- I don't think that's going to hinder your intuition. You've got to handle a lot of your scientific problems through objective investigations, and when you do use intuition, well, you just go ahead and use it. But this is certainly not a reason for keeping out of science. That's why I put it at the end.

Okay, for #27 (reads card aloud) Well, this is just completely false. I think the most critical questions in the world today are scientific questions; and it's not just something that a little boy is interested in that you forget about when you get older. Man is trying to find out what he is and more about the nature of the world in which he lives; he's trying to get more control over the world, and he's got to keep on following science. He's not going to get it by going back to religion or philosophy.

From Brooklyn, Miss Redpath, who has changed from biology to teaching, says simply:

MISS REDPATH: Well, I myself have sort of done away with religious questions in favor of scientific ones; but a scientist should accept both and try to work them in together.

While Mr. Imaji responds to #26, his most extreme negative card rather impressively with the sound of one hand clapping:

IMAJI: Well, see, I'm working here under the ... on the basis of people that I have met whom I consider have reached their realization, you see, that of -- what you would want to call true, through this discipline that they have gone through -- an empirical mastery and things like this. Like, personally, it might have limited, you see, but on the basis of what I've met, that they have taken another road, and I don't think that this, in itself, is misleading to say that you cannot go into a science because this will limit your perceptive powers to penetrate fundamental meanings; and I think that this is wrong, you see, as far as saying positively in this case. I didn't think this in the first place, you see, but I just felt that it didn't satisfy a need within me; and this need doesn't necessarily mean an ultimate satisfying of ultimate limits. I may be confusing you in this. ...

Why is the Inscrutable cluster simultaneously so troubled by social abuse of the scientific role, yet so naive in its faith that, for some, at least, science is "another road" to Elysium? We do not know. But there is a disquieting possibility that the individuals in this cluster, "way out" as it is, may have suffered more in the process of acquiring their early scientific training than did those in the Adolescent and Societal clusters who defected more easily under the strain. In the responses of the Inscrutable cluster, there is an element at once excessively sensitive and excessively unreal which suggests that in their efforts to square their experiences as science students with what science has meant to them as an ideal, they may have been having a pretty hard time.

Chapter VII
Analysis and Conclusions

To complete our analysis we must locate our clusters with relation to the sample group as a whole, link them to the appropriate sub-groups (experimental and control), and then, guided by our original understanding of the questions we have sought to answer, subject the whole to close scrutiny. In establishing such linkages as apparently exist, we will be guided by the data recorded in Tables 10 and 11. We will then re-introduce the three conjectural distributions included in Section C of Chapter IV, and assess them in terms of the relationships they generate with the salient clusters and groups. In conclusion, we shall make such general observations as seem warranted by these findings.

From an examination of Table 10, it is apparent that the two Eclectic clusters stand closest to the position taken by the sample group as a whole. The computed sigma-D^2 value between Eclectic 1 and the total population is very low, being 9.87, and, with the exception of the value for the distance between E1 and E2 themselves, is the lowest sigma-D^2 recorded for all pairs. The second Eclectic cluster also stands relatively close to the sample group and is, as Table 9 indicates, very much like the first for most of its paired placements. The two are not clearly distinct in their response. It was for this reason that we considered them together when discussing the interview material. Together, they represent the hub of our statistical universe. Being at the core, the Eclectics tend more to underscore the characteristics of the total sample than to provide analytically useful contrasts to it. For this reason we have chosen to defer consideration of it for the moment.

We have also omitted the two strange clusters, the Anti-Ideological and the Inscrutable from the analysis, for they provide too much in the way of contrast. Both of these clusters are comparatively small, and both give evidence in their interviews that they represent rather special points of view. We have already called attention to the determination on the part of the Anti-Ideological not to look inward. By these means they seem to have disqualified themselves from serious consideration of the meanings of their lives. They are not the best subjects for a study as to why they particularly had arrived at their decision. Because they do not want to understand the analyst must do their understanding for them. The Inscrutable are even more difficult. They are muddy and inconsistent and both demand and resist understanding. While neither of these two clusters should be forgotten, they belong in limbo. Being somewhat isolated, they add spice rather than clarity to our discussion.

We are left then with the Conventionals, the Old Pros, the Adolescents, the Societals, and the Cool. Of these, the first two stand statistically closest to the controls, and the latter three, furthest from them. This can be readily seen in Table 10. Such a finding is not surprising, of course, for controls are in the majority in both the Conventional and Old Pro clusters, whereas experimentals predominate in the other three. There is no a priori categorical reason why controls should congregate in certain clusters and experimentals in others, however, since membership in a cluster is determined entirely by card placement. That they do indicates that there is a control point of view separate and distinct from that of the experimentals.

When we measure the dispersion of the clusters with the experimental sub-group as our base point, the relative positions of the five are reversed, although the data here are not quite so convincing. Where the Adolescent has a sigma-D^2 value of 11.84 as measured from the experimentals, the Societal and Cool both have values exceeding 19.00. This is not sharply different from that of the Conventionals, whose sigma-D^2 distance from the experimentals if 21.21. The Old Pros stand farthest from the experimentals with a value of 27.16, but not as far as the Cool and Societal do from the controls.

On Table 11, the inter-correspondence between the Adolescent, the Societal, and the Cool is marked. The extent to which they individually stand away from the Conventionals and the Old Pros is also obvious. Together, the sigma-D^2 values for their separate pairs range between 15.1 and 25.2 as against the scores recorded when the three are paired with the Conventionals and Old Pros. The sigma-D^2 value between the latter two is 29.3, while the other three clusters have values which range between 44.2 at the minimum, to 67.7. It is for these reasons that we have decided to let the Adolescents especially, and the Societal and Cool speak generally as important varieties of the experimental point of view, and the Old Pros especially, and Conventionals speak for the controls.*

Hypothesis B, as introduced in Chapter I, states in part that students who abandoned their careers in science primarily for the reasons suggested in Hypothesis A(1) will resemble in their total attitude toward science highly successful students who continue their scientific work more closely than will those who left under the influence of reasons similar to those contained in Hypotheses A(2) and A(3). We have already stated that we do not feel that this hypothesis has been confirmed by the study. In fact, we feel it has been clearly refuted.

Our reasons for taking this stand are bound up with Professor Friedenberg's three conjectural card sorts. While the sample group as a whole conforms more closely to the distribution purporting to describe the crucial A(1) reaction than it does to the other two,** the actual quantitative discrimination, when broken down in terms of experimentals and controls, contravenes what is suggested above by Hypothesis B. In their attitudes, the controls, both as a sub-group and when represented by the two cluster, Old Pros and Conventionals, turn out to be less like Hypothesis A(1) than do the experimentals, the Adolescents and the Societal. Accordingly, highly successful students continuing their scientific work are, on the whole, less inclined to be concerned about conditions that would seem prima facie to be limitations on the free play of their integrity and spirit of inquiry than are those who have abandoned the field. More emphatically, Hypothesis B fails through a shortage of science students (herein, controls) who have a noble and sensitive vision of themselves and their place in the universe, not through a shortage of individuals who are so concerned. We have a number of the latter but, except for one or two unique subjects such as Mr. Bond, they have left science for other fields.

The statistical evidence for this assertion is recorded in Table 12. Therein, we find that when measured from the conjectural distribution for A(1) the sigma-D^2 value for the experimentals is 33.81, whereas that for the controls is 46.72. Turning to the relevant clusters, we find that the Adolescents stand closest of all clusters to A(1), and except for the two Eclectics, the Societal and the Cool stand next. The two latter, however, do not follow the conjectural A(1) profile as closely in their mean card placements as do the members of the experimental sub-group. Two cards, #8 and #21, account for a major share of this divergence and will be discussed more extensively at a later point in this chapter. For the three varieties of the experimental position, the sigma-D^2 values are, respectively, A= 31.36, S= 44.41, and Co= 59.73. The values are hardly greater for the two control oriented clusters, than is that of the Cool, for the Old Pros register 60.90 and the Conventionals, 67.49. Thus, by rank specifically, and to some extent by the measured distance, the results are consistent. On the whole, the experimentals stand closer to the conjectural distribution for A(1) than do the controls.

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* We have already been doing this in the text. Mr. Hughes, who opens the discussion in Chapter V is a member of the Adolescent and Societal clusters, and Messrs. Grant and Perry are also in the Adolescent. Mr. Rabinow is both an Eclectic and a Conventional, and Mr. Wheeler is an Old Pro. Mr. Byron, with whose interview we have concluded the chapter, is a member of the Cool cluster, but is atypical in that he is the only member of that cluster who is also a control. The overall organization of Chapter VI has also been determined by the reasoning incorporated above.

** The sigma-D^2 value between A(1) and the Sample group is 37.26. For A(2) it is 74.85 and for A(3), 57.65.

Without question, this method for establishing inferences from data places a heavy burden on the conjectural card-sorts, and for this reason, we must consider to what degree they may bias the verdict. We have called them"conjectural" because we felt that we had no entirely satisfactory technique for constructing them. They do not and cannot perfectly capture our elusive parameters. They are simply attempts to define three specific attitude configurations through the use of the 32 cards. They could have been drawn up inductively by asking a selected sample of the subjects to sort the cards "as if" they had the three attitude configurations. We felt though that such a method, while it has some merit, is functionally astigmatic and would tend to distort the findings. The subjects would be likely to find it difficult to keep their own feelings out of the response and to maintain the discipline of "as if." Instead, the sorts were made by Professor Friedenberg, who worte the 32 statements in the first place. While it is clear that his sort also would have its limitations, it is reasonable to suppose that his predilections would not be exactly the same as those of the subjects themselves. He is not a member of the present generation of students in or once in natural science but of an earlier generation; he began the study of such students with certain ideas about what he might expect to find; and he has experienced the cards as their author, not as a subject facing them for the first time. For these reasons, discrepancies and incongruities, as well as correspondences between his conjectural card-sorts and those of the representative groups and clusters are worthy of serious consideration. All are clearly sources of information about the subjects' frame of mind in making their choices.

Close inquiry into the actual card-sorts adds support to our previous assertion relative to Hypothesis B. In making the conjectural sort for A(1), card #27 was chosen as the first, or most positive reason why one might leave a science major and was followed in the second category by cards #25, #26, and one other.* All these are among the cards discussed in Chapter V relative to differences between the experimentals and the controls**. They are all cards which the experimentals as a group favor. Two of them (#26 and #27) are treated as trivial by the controls and the third (#25) as ridiculous or misleading. They are also cards which characterize certain of the clusters. Both *Adolescents* and *Societals* treat the three as significant *** on the positive side and in addition, add a *fourth*, #28. Furthermore, card#27 is the first or most favored of all the 32 cards for each cluster. None of these cards is treated as significant by the *Old Pros* or *Conventionals* except for #25, which the *Old Pros* don't like.

These four cards are of a piece. They present reputed shortcomings of the scientific method and stress its discipline. Taken together, they emphasize the restraints imposed on "the free spirit of inquiry" by the method. Number 27 also, with its emphasis on the questions he *must* ask, introduces a somewhat indistinct element of "integrity." Unfortunately, it also tends to treat the scientific method as if it were a juvenile form of self-expression, and might thereby appeal to those who prefer to express an attitude of studied contempt towards their former field. Mr. Bond, however, can hardly be accused of such an attitude when, in response to #27, he says:

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* The one other is card #18. It is not our intention to attempt to be exhaustive in this phase of our analysis. For the reader who is so inclined, all the necessary material for close analysis is available in the several tables. Card #18 will not be discussed in the text at this time because it is not especially discriminating. However, it is one of the two most popular cards and will be taken up later in a different context.

** Cf. chart II, p.51, above.

*** The convention we have chosen to use throughout the paper when discussing clusters is to describe any mean card distribution that is less than 3.0 or greater than 5.0 as being significant.

> BOND: Well, I believe this, too, because we're in a scientific world and that's taken for granted, but here's what's good and I'll quote this; "but when he" ... this person pursuing science ... "gets far enough, he may well find that the questions science can answer are no longer the questions he must ask." And I believe this; that the ennervation of the external Maxillius muscle, if I discovered this, to me wouldn't be the end of man. To me, it's for what purpose am I here, and can I lead a good life, or does a good life exist, and things like this exist in relation that science should be applied to them, I think.
>
> INTERVIEWER: As an exploratory device?
>
> BOND: As an exploratory device. Science is not an end in itself to me.

Nor can Mr. Tudor, another member of the Adolescents, but not one who has previously been quoted. In response to #27, he says:

> TUDOR: I like to work with things, materially with things: and there it was. Science is extremely easy to use; it's oriented around, you know, high school people are being pushed into science to some extent , and there are ready opportunities -- amazing, the things you read -- and you can't help picking it up if you like this sort of thing. So I got into it for a long while and I intended to major in engineering when I came here and then I just ... I can't say that I've lost interest in it ... . it's just that I found myself wanting to get into something a bit more expressive which is why I switched into music. But, this is ... the reason I told this just from my own standpoint, that I didn't find science stimulating enough for my own desires to do it.

These are decent, thoughtful young men. While it would be difficult to determine how much the positive response to #27, in general is a matter of personal integrity and how much a matter of vanity, it is reasonably clear from such comments as these that there is a great deal of it that is not vanity.

Card #25, which has elicited diametrical opposition in its response, specifically mentions the classroom and emphasizes objective methodology in the sciences. It also calls to attention a second card over which opinions clash. This is #23, and here the clash is multidimensional. In the conjectural sort for A(1), #23 is treated as trivial. Yet the experimentals favored it and the controls found it ridiculous or misleading. It is also placed positively by the Adolescent and the Cool and negatively by the Old Pros, and for this reason becomes the source of one of the discrepancies between the conjectural card-sort and the patterns established by the subjects.

Card #23 is similar to #25 in that it stresses the classroom and the degree to which the conditions under which a natural science education is carried on offers little encouragement to independence of thought. It is through the classroom and the laboratory that the students experienced science as an institution, and it was there, it seems, that many of them experienced their disenchantment with science. A very interesting interview between Miss Newton, a member of the Adolescent cluster, and Mr. Friendly, who, for what will be obvious reasons belongs to no cluster, illustrate this phenomenon with their discussion of card #23. (Mr. Friendly placed it in pile 6, Miss Newton in pile 3) :

FRIENDLY: I think to go into science, you have to believe in the scientific method. This is a part of your philosophy and, as such, you realize that it is a means to your ideas and you realize your complete inability to obtain any ideas unless you do reach them by the scientific method. Therefore, you feel impelled to learn these tools which are going to bring you closer to the ideas.

MISS NEWTON: Yes, but while you're learning them, I still think that there's little encouragement to independence of thought, at the time. Maybe when you have to use the tools, you definitely have to ...

FRIENDLY: Well, again, let me say that the reason I put it in the rejection pile, I left to a certain extent the training aspect in speaking of overall broader terms. A person who does not recognize, but who really wanted the ideas immediately, I think in many respects would be discouraged, because you concentrate on the tools and the methods more than the ideas at the beginning.

MISS NEWTON: I agree.

FRIENDLY: But I still say and maintain that you don't have to lose that if in your own mind you will recognize that later the ideas will come.

MISS NEWTON: It does get lost for many students because there is so much being crammed into you all the time. You don't have time for outside activities, interests, and you don't have time to puzzle over what you are learning and if you take a science course in a strict curriculum, there just isn't time.

FRIENDLY: Well, I just can't agree with you there, because I found time to ... in the midst of organic chemistry and comparative anatomy and physics, to talk about philosophy and ...

But in a sense, he does agree with her. This reads as if Mr. Friendly is a noble devotee of science, engaged in an unsuccessful struggle to convince Miss Newton against her will that she ought to have been more patient with biology. This may well be. But Mr. Friendly is a member of the experimental sub-group himself. He is a pre-med student majoring in economics, and gives as his reason:

FRIENDLY: I would say that the big reason is the fact that I thought that going into medicine, you tend to become narrow in your interests, especially for the medical school years, you're confined to a certain areas, and I wanted to develop some sort of interest in another area, so that eventually, I could pursue that when I had more time.

Twenty-three is the card that Mr. Perry and Mr. Wheeler discussed in Chapter V. There, it was pointed out that in their comments on the nature of the experience undergone, they generally agreed. The contrast is rooted instead in the attitudes they developed in the course of this experience. The controls willingly accepted the discipline imposed without accompanying clarification and buckled down to work. And because they are capable, their technical development is undoubtedly of high quality. On the other hand, it is against this same discipline and especially against the suspension of understanding it seems to entail that the experimentals rebel.

All this sounds very virtuous on the part of the controls. Nevertheless, other comments by the *Old Boys* are not so encouraging, for we must remember that it is this same Mr. Wheeler who, when asked about pressures from management which might run counter to the scientist's interests, replied: "I think resignation is probably the best thing." The control interviews suggest that by the time they are ready to graduate, their inclinations to submit their will to non-rational or unconsidering authority has become something of a habit for many of them. They have an aptitude for adjustment. Miss Sharpe, of the *Old Pros*, sums up her interview in this manner:

> MISS SHARPE: When I first went through the cards I thought a great number of them were not very, well, were thoughts that I never had before of why I wouldn't go into science. And if I hadn't had that job in industry I wouldn't have ever realized that science can be monotonous.

Our controls, especially as represented by the *Old Pros* are not disposed to be critical. With little complaint, they accept the scientific method as well as the conditions under which it is conventionally practiced and go about their business. For these reasons they reject statements such as those on cards #23, #25, #26, #27 and #28. They are not insistent on the priority of their own feelings or their own ideas about the activities in which they were engaged. In doing this, they are willing to surrender their rights, possibly their responsibility to exercise any "spirit of inquiry." They fit in their environment and have no special urge to find themselves. They seem to have no great problem in coordinating a variety of interests. It is here that they most sharply contrast with those experimentals best represented by the *Adolescents*. For it is just such a spirit of inquiry, just such a nagging need to *find out* that has played the pied piper to the latter. They cannot rest at peace with themselves. This point was probably best said by Mr. Hughes, who, along with Miss Newton and Mr. Bond, certainly has his union card. For he and they are members of both the *Adolescent* and the *Societal* clusters.

> HUGHES: I said before there were two circles: there was my studies and my interests. Now I have one and it's a considerably bigger circle. I have an awful lot of interests, but somehow they all tie in, and I feel this. I mean, it's just round; it's nice, inner calm peace and perfectly satisfied. I know, in general, where I'm going and how I'm going to get there. I know what I like and, in general, of course, this is always changing, it's expanding. I find more things. I open another book, I learn something else, so there's nothing static ... it's not because I didn't like engineering. I have an awful lot of respect for it, in fact, I have an awful lot of respect for the guys who can just, in a sense, throw away their lives and settle for just having things cut out for them. ...

Two sub-patterns of card placement within the conjectural profiles contribute further to both the contrast and variety of response by the sub-groups and the representative clusters. The first of these refers to the disposition of cards #1 through #4, and the second to that for cards #8 and #21. Cards #1 through #4 are the "money" cards. In the conjectural sort for A(1), they were all placed in piles five and six, whereas for A(2) they were placed in piles two and three. Thus, they provide one basis for a contrast between a conjectural A(1) attitude configuration and a conjectural A(2) configuration.

Except for #1, which is possibly too shallow to be taken seriously, all of them appear on Chart II as cards in which the distance, when measured in terms of standard error, between the means of the controls and experimentals differs significantly. When we turn to the representative cluster, we find that the results are even more dramatic. The *Adolescents* utterly reject these cards; only two others are as unpopular with them. For every card, the mean for the pile placement exceeds 5.0. The *Societal* and the *Cool* are almost as emphatic in their negative feelings toward these cards. On the other hand, the *Old Pros*, again, except for #1, are consistent with their previously described positions and agree that the statements on these cards represent something in the way of sound advice. And for their part, the *Conventionals* agree with the *Old Pros* on #2 and #3 and are relatively indifferent to #1 and #4.

Table 1
Composition of Groups Included in Study

	Brooklyn		Ohio State		Stanford		Total
	X	C	X	C	X	C	
Science	10	10	10	15	15§	4	64
Engineering	*		24	11	16§	6	57
Total	10	10	34	26	31§	10	
School Total	20		60		41§		121

* Engineering courses are not offered at Brooklyn College; students preparing for engineering transfer to the City College, ordinarily during their junior year. One student in the experimental group had, however, originally planned to become an engineer.

§ One Stanford experimental engineer and one scientist refused to complete the card sorts on the grounds that they could not conscientiously sort the cards according to the directions. N for IBM purposes is therefore 119 rather than 121.

In many respects the experimental and control groups are very different. Our procedure is not a true experiment in the sense of the application of a variable to two equated groups, but a way of investigating the ways in which members of two different groups that are of some social importance resemble or differ from one another in their reactions to being trained as scientists. For our purposes, there are just two qualifications for membership in our experimental group: (1) the student must have been seriously committed to a career in the natural sciences or engineering and have gone far enough in it to demonstrate some promise; and (2) he must have changed his career of his own choice. How an individual could be identified as meeting these criteria was partly a function of the way in which the institution we were sampling kept its records, and the other sources of information available to us. But we were obliged, in any case, to accept these students as they came because we did not know how the progress of their disaffection with science would manifest itself, and we would have run a very serious risk of excluding the very people we wanted to study if we had imposed any further criteria on the sample. We were, for example, certainly more interested in the occasional student who had left science even though he had a brilliant record as a student than we were in one whose record was unimpressive. But we could not exclude the merely promising student from our sample because underachievement and falling grades are amongst the commonest consequences of dislike of a field of study and are often the best indication that a student is turning away from his earlier choice -- sometimes before he is aware of this himself.

We conceived our control group, however, as composed of model students, students who were responding to their education with distinction, satisfaction and achievement. Rather, therefore, than try to match the characteristics of the students who had, in fact, changed and were included in the experimental group, we tried to get the best and most promising science students that we could.

We used slightly different procedures at the three campuses from which our subjects came, according to the way in which its records were kept and the informal sources of information and kinds of cooperation available to us. At Brooklyn College, we identified our experimental subjects from two sources: a questionnaire that had been given to the graduating class of June, 1958 for quite a different purpose on which these students were asked to indicate any change in major; and examination of transcripts of all undergraduates classified as seniors for the academic year 1958-1959. We invited every student there were about 35 -- who had changed from one of the natural sciences to the

In making this distinction, Mr. Byron calls attention to a point that many subjects mentioned during their interview, although they seem to have had difficulty in expressing it through their card choices. Again and again those who had left science mentioned that they preferred working with people rather than with things, and that the life of the scientist did not give them sufficient opportunity to do so. Only the *Societal* and the *Cool*, which are, after all, the clusters most critical of science as it is institutionalized, managed to formalize this objection through their card choices. Over 1/3 of the sigma-D^2 distance that separates their profiles from the A(1) conjectural sort is accounted for by these two cards alone.

One important incongruity remains, the one that is possibly the most important of all since it refers to the sample group as a whole.* Cards #18, #17, #6 and #9 are the four most popular cards for all subjects in the sample group. Except in the case of #6, there is no significant distinction between the way in which they were placed by experimentals and controls. Yet, when constructing the conjectural card-sorts, Professor Friedenberg treated three of them as trivial. Thus, they constitute a relatively unexpected and significant statement about attitudes held by the subjects, and, furthermore, one on which most of the subjects are in agreement.

These are the cards with which we began the discussion in Chapter V, and they are mentioned again and again by the subjects throughout. They, too, are of a piece. They suggest that "scientists don't get much chance to participate in making the decisions that govern their work"(#9); that only a few scientists "are able to get on top of an entire problem" (#18); and even then, "scientists have to be prepared to accept having their most basic work subordinated to the demands of administrative policy" (#6). Consequently, the work that most scientists do is likely to be "dull,routine activity" (#7). Circumstances such as these are the source of Mr. Rabinow's *ennui*, and it is this to which Mr. Wheeler expects to become resigned.

The system that has seduced them will surround them. It will arrange their lives and comfort them with the small apples of amenity, and then will slowly drain what little blood they have from their veins. Unfortunately, both for themselves and for us, the experimentals and controls agree on this. They only disagree in their response to these circumstances. The experimentals make it clear that they feel their independence is threatened, their persons violated, and they run for cover. The controls, on the other hand, resign themselves to success, and go about their business with what good humor they can muster.

The only escape, for those who stay in, is to be a genius, and who is? On that, most of our subjects, whether controls or experimentals, have given up. Miss Pollock, of Brooklyn College, an unclustered control who believes in beauty and hates mathematics because "you don't need a picture" for it, touches on this in her discussion of card #17:

> MISS POLLOCK: Well, I chose this because not all people that go into science are maybe geniuses and if you are not a genius ... I don't know, I haven't had too much experience, but just like in anything else, you get stuck with the dull things.

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* The conjectural A(3) cluster has been ignored in this analysis. Of the four positive cards deemed to identify important A(3) characteristics, three are outstanding in one odd way. Only six cards out of the thirty-two are not significant for some group or cluster, and three of these six, #24, #19, and #29, were placed in piles one and two of the conjectural card-sort. In other words, the sample group as a whole displayed a massive indifference to these three cards. The fourth positive card, #30 -- religion versus science -- is a different story. It is the second most unpopular card of all, but is not especially discriminating. It is important not so much for the light it throws on questions central to the issues being discussed herein, but for the inferences that can be drawn from the response to it about the role of religion in America today.

Mr. Eero and Mr. Harcourt, while disagreeing on the meaning of dullness itself, agree on what the future has in store. When asked for a significant piece of advice to add to the cards, Harcourt answers:

> HARCOURT: I'm trying to form it into a positive statement of some sort. Perhaps, that the ... a statement to the effect that the sciences do not seem to offer one, as, as a field, as personal a contact with one's work which might have deeper personal significance, as the arts.
>
> INTERVIEWER: As much subjective meaning?
>
> HARCOURT: Yes, I think that one can derive a subjective meaning from them only at a very high level of competence, much higher than one need reach in the arts to gain a subjective satisfaction.
>
> INTERVIEWER: Mr. Eero, is there anything you would add to this?
>
> EERO: Well, my first point would be, of things not contained in the cards, and that is abilities. If one doesn't have a particular aptitude for sciences, it seems to me, it would be rather, since I was in engineering, would end up on a drawing board or something not particularly exciting. I think unless one has a better than average ability in the sciences, it wouldn't be very rewarding.

And, in conclusion, from Ohio State, we have Mr. Lawton, who had taken a pre-medical course, but, feeling inadequate in mathematics, left it for another field. He comments on card #18 as follows:

> LAWTON: Well, this seemed to me to be about the most ... compatible with my own feeling about the rigidity of some of the physical sciences and the fact that you are supposed to commit ... yourself to certain very rigid formulae, principles, minutiae and this is the thing at least I find distracting because I'm still interested in the sciences and yet this kind of thing of the assembly line-ness ... the discouragement I think that's often except for the very few really top, deep, unusual thinkers, the genius level which I certainly am not.

That about sums it up. There do not seem to be many who even have the courage to dream that they might be. There is, we think, a significant group of subjects who conform well to the conjectural A(1) profile, and who give evidence from their interviews that they are concerned with person self-integration and the maintenance of a healthy spirit of inquiry. It also seems, from the evidence, that most of them found it necessary to leave the sciences if they were to maintain their vitality. Therefore, the findings suggest that there are only a very small number of persons remaining with a science major who have concerns similar to the significant group of those who have left. Most of the rest who have remained have settled for something less than self-fulfillment. And, over all, both with those who leave and those who remain, a certain weariness prevails. Almost nobody, nobody except for Mr. Bond and Mr. Grant, at least, wants to change the world. Some think it's great as it is. The significant few want at least to take a hand at making themselves and to accomplish this most of them leave for a pleasanter academic climate. The many, on the other hand, are willing to let themselves be made by circumstances.

A question that cannot be answered deserves at least to be remembered and reasked again. This is, whether there are, among those who were encouraged by circumstances to leave the sciences, some who are potentially creative scientists and who could and should be salvaged? While we have no answer to this question, we do have one tantalizing bit of evidence to present. It is in the form of a statement by one who is acknowledged to be a creative scientist, and we will leave it to the reader to decide in what cluster, if any, he belongs. In discussing his college education, Professor I. I. Rabi, Nobel Laureate, has this to say:

> . . . In a sense, I never really went to college at all. My undergraduate degree is a Bachelor of Chemistry from Cornell -- a degree by the way that, like the DeSoto, has been discontinued. My course at Cornell included Freshman English and, apart from that, nothing but chemistry, mathematics, and physics. It is in this sense that I can truly say that I never went to college, certainly not to a liberal arts college. . . .
>
> As an undergraduate, however, I discovered that, if you did not go out for grades and were somewhat independent of mind, you could get for yourself an education. So it was that I early formed the habit of never reading a subject in which I was taking a course. I let the instructor, who presumably was master of his subject, lay out the course for me. I simply attended class, listened carefully, took careful notes, and that was all. If ever I was interested in this subject again, I had a solid starting point. Meanwhile, if the course was in -- say, organic analysis -- I might be reading my way through Shaw or Shakespeare. Of course, just before the examination you pulled out those notes, did some intensive scanning, reflected a bit on what the instructor could possibly ask -- the questions could not be too detailed, it would be unfair -- so that, with a general view of the subject, you could march into an examination and get a decent gentleman's grade. To get A's of course meant that you subjected yourself to his kind of thinking, and sacrificed your independence of mind. And so it went. Afterwards, matching myself against the graduates of the liberal arts colleges, I decided that, though this training may have been bit hodge-podge and unconventional, I was certainly not uneducated.
>
> I had, moreover, one great advantage over the liberal arts graduate. There was something I knew. I really knew Chemistry. I knew a lot of Chemistry. I knew how it hung together. I knew its separate parts. I knew it as an intellectual discipline and as a system of thought. I am not, of course, suggesting I knew all about Chemistry, but I knew enough about it to feel confident that I knew something, and that I could go out and do something about it. And, as a matter of fact, I once did get a job in a laboratory where I analyzed mother's milk and furniture polish.*

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* Rabi, I. I., Graduate Faculties Newsletter, Columbia University, February, 1961, p. 3.

Chapter VIII

Postlude

Recently, Professor Lee E. Danielson prepared a report on the characteristics of engineers and scientists for the Bureau of Industrial Relations at the University of Michigan.* In a sense, his work is a logical extension of the work in our study, for he is concerned with individuals who are already filling occupational roles in industry. For his report, Professor Danielson administered a set of comprehensive questionnaires to executives of ten large companies employing engineers and scientists and to both supervisory and non-supervisory engineers and scientists employed in these companies. Through his questionnaires, he sought to determine what job activities were satisfying or dissatisfying to the engineers and scientists, along with the reasons for these feelings. While several of the points developed and discussed by Professor Danielson are of considerable interest, one stands out dramatically when considered in terms of evidence contained in our report on why science students leave science. Professor Danielson has the following to say:

> Only ten interviewees (out of 75 technical supervisors and 170 non-supervisory engineers and scientists interviewed) specifically mentioned a difference in desire for self-improvement, and then proportionally more supervisors than non-supervisors made the comment. This low frequency of mention and the disproportion are not coincident with the theory that many engineers and scientists are self-motivated people. There are several possible explanations. One is that a number of the interviewees neglected to mention self-improvement specifically because it was obvious that if they were to achieve other goals, self-improvement would be necessary. Another is that the phrasing of the question did not elicit responses which could be classified as a desire for self-improvement, or the strictness of the classification system may have limited the number of responses that could be categorized.
>
> Still another explanation that could cause managers some concern is that perhaps these professionals really do not desire to improve themselves, at least not to the same extent that managers would like; this could explain the higher number of responses by the supervisors. Theoretically, these professionals are hired because they have given some indication of self-motivation, and they should desire to improve themselves. Actually, however, a number of presently employed engineers and scientists may improve only as the situation demands, rather than because of an inner desire. This could be a reflection of the preparation they are given in college, or a function of a selection process which does not select only those who desire to improve themselves, or the result of demands off the job which consume the professional's time and energy.**

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* Danielson, Lee E., Characteristics of Engineers and Scientists, Bureau of Industrial Relations, the University of Michigan, Ann Arbor, 1960.

** Ibid., pp. 22-23.

Despite his beginning apologetics, Professor Danielson finally comes around to reasons roughly consistent with those developed in the main body of this study. There is evidence of a selection process, and it operates to encourage those who are interested in self-improvement to seek employment elsewhere. In college, students who are successful are very often successful because they are not self-motivated. The crusaders and those who seek to serve change their majors before they have ever become employable. They never qualify as members of Professor Danielson's sample. And the field is left open to those who find it easy to satisfy requirements. This, to say the least, is discouraging. And, in a tense world, it possibly bodes ill for all of us.

We are not nationalistic enough to wish to keep in science the ardent and promising youngsters who leave it, nor even convinced that it would be in the national interest, whatever that may be, to do so. But it does seem to us that the experiences that drive them out have far less to do with science as either a method or an epistemological system than they have to do with science as a social institution. Those of our best subjects who left did so because of the way scientists are taught and the way they are used, not because of what science essentially is. It is Mr. Harcourt, not Mr. Eero, after all, who is correct in believing that science deals with deep and fundamental issues of being. But undergraduates do not get much chance to get down to fundamentals; and Mr. Harcourt, who had a straight A average in biology when he decided to quit, left, too.

It would seem that the sensible way for a nation to retain such youngsters as future scientists and engineers would be to try to improve the way they are taught and to modify the opportunities open to them in their later employment so as to provide a legitimate expectation of personal autonomy in work. But this is not the way our culture is actually going about it. Instead, subject after subject in our study complains that the way the high school led him into science confused him and made it much harder for him to see just how his career choice was going to affect his life and his image of himself. From the point of view of an adolescent, considering what it is he has to do to grow up, this is a very serious charge against secondary education. We have already quoted Mr. Swanson's rather straightforward comments on this issue. Mr. Perry is a bit more sardonic:

> INTERVIEWER: Why did you not start in commerce (to which Perry has changed)?
>
> PERRY: Well, I think it's just because all through my high school that we had sort of the idea that the, you know, the engineer was the person that was -- actually, it was just a bunch of propaganda -- that the engineer was the person who was going to be successful, and if you wanted to be the type of person that industry was really looking for, so to speak, that ... it was an engineering graduate, which I fully believe now is entirely a fallacy ... I don't -- nobody actually told me this, but it just seemed to be the general concensus of opinion that if you're doing favorably in math and come from a school like Arlington, which does have a very high percentage of its graduates go to college; that if you were a boy and did well in math and had a natural adaption (sic) for mechanical drawing, well, that "you just come over here and be in engineering" ... (then, in college) I just began to think, well, now, if doing 20 calculus problems every night, that it's just sort of busy work, really, and, well, I just didn't like it at all; I began to think: "Well now, is this what I'm preparing for?" and if I'm going to be using this after I graduate, I don't even want to be using it after I graduate. And so, if I'm not going to use it, why am I doing it now?

Mr. Hughes, at the opening of his interview, in response to the "Is there anything that has been left out that you would care to add" probe of the Interviewer, states flatly:

HUGHES: Now, my decision was made on the grounds that I didn't want to be an engineer -- that I wasn't an engineer -- and my reasons for being in engineering lie, inherently, in the California state public school system,* it being that for the person of above average ability and interest there are only two outlets in the curricula of the California high schools which allow for any expansion, any room to vent any extra ability and interest -- and these are math and physical science fields. Almost all the other, without exception, in most of the high schools, keep you well under wraps. You're pushed down to a level of mediocrity, and there's no chance to do anything more. However, in these particular fields of math and science they open a few doors and there are places you can go, things you can do, books you can read, people to talk to; and my last two years in high school were spent preparing for an engineering career. Everyone said: "You'll make a great engineer!" ... It's a very easy process; I've seen so many of my friends. Now, in our graduating class, we had 77 people, and of the about 30 boys in that class that went through the last two years with me in math and science classes -- same group went all the way through -- there are two left in engineering. One is in electrical engineering, because he's on a naval scholarship and they won't let him change to architecture. The other one is somewhere else -- in civil engineering, I believe, for the same reason; he's on a scholarship and they won't let him change. One of the fellows changed to pre-dental, other people have gone to other fields, some have lost interest in general, and don't know just what they want. But so many go in; it's easy, it's nice. "Oh, you're going to be an engineer, scientist!"

Of course, sometimes the process works, and when it does, the experience may take the form described by Mr. Valcic, esteemed at Ohio State as one of its best young chemical engineers. Explaining his career choice, he says:

VALCIC: Well, in high school, I took an examination with an employment bureau in which our skills were investigated. I was told that I had the ability and understanding of knowledge to do just about anything. And so, well, I had been interested in the scientific field, engineering and so on. I took a scholarship test and received a scholarship to go into chemical engineering. Well, since I'm in it and I am having all my education paid for, it would be somewhat foolish to go out of engineering considering that I have the ability to understand engineering as such and to me, it doesn't make too much difference in what field I actually make my living. Personally, if I hadn't gotten this scholarship, I would have gone into agriculture. Not to have come to college and studied, but just started farming. Try to run farming as a business rather than just a way of life.

Mr. Valcic, we think, may be allowed to have the last word. It figures.

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* Technically, Mr. Hughes should have referred to the County School system; California schools are not organized into a state system. For a statistical summary of attitudes about science education in another California country system, cf. Paper 1868, "Six Thousand High School Students View Engineering and Scientific Careers," Journal of Professional Practice, Proceedings of the American Society of Civil Engineers, Dec., 1958.

Appendix I

Q-Sort Cards

1. Scientists make too little money in the course of a lifetime, compared to people in other professions, to justify the costs of getting a Doctor's degree.

2. Scientists' salaries may seem high enough usually, but since they usually work for a company or a university on a pure annual basis, they have much less chance than doctors, say, or lawyers, to do well for themselves.

3. Over a lifetime, perhaps, a person with a PhD in one of the sciences will earn about as much as other professionals; but it takes him so long to get up there with the others that he and his family have quite a struggle.

4. As professional people, scientists have to expect to move socially among people who earn just enough more than they do to keep them in a state of mild but unpleasant tension.

5. People are really pretty ambivalent toward scientists. Officially, they are highly respected, but the stereotype of the mad scientist is seldom wholly absent from the mind of the man in the street.

6. In modern bureaucratic life, line always pulls more weight than staff however competent or eminent. This means that scientists have to be prepared to accept having their most basic work subordinated to the demands of administrative policy.

7. For the word "professional" to have any real meaning, it has to imply that you can set up in private practice if you find your job turning trivial or harmful. A scientist today may be an expert -- he has to be -- but he can't hope to be a professional in this sense.

8. Scientists don't seem to live like other upper-middle class people even when they are quite successful. They tend to have fewer interests outside their work in things like the arts, or even in other people, so that life can get pretty dreary.

9. Scientists don't get much chance to participate in making the decisions that govern their work. Once the problem is set, they need all their creativity; but when it comes to having a say in where the whole project is going, they don't sit very high on the committee.

10. It is interesting the way, in all those discussions of Soviet education, the American people seem to equate the words "scientist" and "technician" -- not a bad indication of how little the scientist is expected to have to say about running his own show.

11. Basically, a scientist's career depends on his capacity to do significant research; that *is* his career. But fundamental research is so costly that in order to do it *he* has to be just as talented at fund-raising as he is in his field. These two kinds of competence are so poorly correlated that many scientists who might do the most creative work get hardly any opportunity to do it.

12. Some of the satisfaction of success for a normal human being comes from being recognized as the responsible leader to whom subordinates turn for guidance. There is too little of this in the way scientific research is usually conducted today; what isn't strictly impersonal is teamwork.

Appendix I (continued)

Q-Sort Cards

13. Not many scientists can dare to lead a normal political life when they know that their career may be seriously set back, no matter how competent they are if they are charged with being a "security risk."

14. The career of all scientists has been made a little more difficult by a few disaffected "liberals" who have sapped public confidence through their political naivete. Most scientists are loyal, and recognized as such; but the attempt made by some to exploit the few misunderstandings and injustices that have inevitably occurred in order to harass the entire security system has left a bad odor that will not soon be dispelled.

15. There is not much room in science today for the true conservative. The climate of opinion in the scientific world is such that an individual who shared the American people's recognition of the need for vigilance imposed by the Cold War would be given a pretty hard time by his colleagues.

16. The career of the scientist has gradually become more insecure as the center of scientific activity has shifted from the university to industry and government. In industry and government, there are no such institutions as tenure and academic freedom. Even though he is, broadly speaking, an intellectual, the scientist can count on no safeguards of this kind.

17. The work of the laboratory scientist is less varied and engrossing than the image of the pioneer serving mankind in his laboratory would lead you to expect. Most scientists spend most of their time in rather dull, routine activity.

18. Most scientific work today is carried out on more or less of an assembly line basis. Only the top scientists in industry or a few in university work are able to get on top of an entire problem; the rest of the "team" have to hammer away at their particular part of the job without really getting much of a "feel" for its overall purpose.

19. Despite all you hear about automation and the atomic age, there is something peculiarly old-fashioned about the scientist's job. Socially speaking, science as an institution is back in the stage of inner-direction. Maybe nobody needs the glad-hand and three coffee breaks a day, but people do get used to having them, and the atmosphere of lab, library and seminar seems awfully austere by modern standards.

20. People who think of the scientist as a "seeker after truth" are likely to be disappointed because scientific truth has become something so different from anything that can be described or can make its validity felt intuitively. There is seldom any "shock of recognition" when a scientific proposition is verified; it is altogether too abstract.

21. While there are many exceptions, groups of scientists are generally not as pleasant to be among as other intellectuals. On the whole, they tend to be stiffer and somewhat less broad-minded and sophisticated; they hardly seem to know how to enjoy themselves.

22. Compared to other disciplines, the sciences seem to operate within a rather authoritarian tradition. Status is more heavily emphasized; professors

Q-Sort Cards

are a little more pompous, graduate students tend to be more deferential. It isn't so important in itself, but it hardly adds up to an attractive style of life.

23. Contrary to what one usually expects, scientific training actually seems to offer little encouragement to independence of thought. There is more lecturing and less discussion than in other disciplines; the examinations tend to be rather petty and factual. Even the lecturer's jokes are listed in the syllabus.

24. Even persons who feel themselves ready to accept the traditional austerity of the laboratory are likely to underestimate the degree to which the scientist is expected in his work to detach himself from ordinary human concerns. It is not that scientists are less the prisoners of their own personality or less likely to be "operators" than members of other professions, but that the whole idea of using your skill to work with other people and serve them is held in low regard.

25. The scientific method, as it is taught in the classroom and thought of by the general run of scientists, actually hampers efforts to understand many problems. Insight into the way things develop and their unique, particular meaning are sacrificed to rigid experimental control and statistical generality in order to keep the research scientifically respectable.

26. The scientist's commitment to place objectivity first, while it has made science the instrument of empirical mastery of the environment, ultimately limits his power to penetrate to fundamental meanings. With so much of human experience tending toward depersonalization, it is just those perceptions that cannot be "consensually validated" that are often of crucial importance.

27. An interest in science is, to some extent, something many people in this culture ought to grow through. An American adolescent, if he has any spontaneous curiosity about the world he lives in at all, almost has to couch his interest in scientific terms, for these are the terms available. But when he gets far enough, he may well find that the questions science can answer are no longer the questions he must ask.

28. It is naive to assume that the scientific method leads to the discovery of the kind of truth that is of most fundamental importance. Empirical research is of the greatest value as the instrument of prediction and control of nature, but it is on untestable, transcendental or theological concepts that life ultimately depends for its meaning.

29. Scientists traditionally accept very little responsibility for the use finally made of their work. This was understandable and perhaps acceptable a century ago when human rationality and progress were generally assumed to be marching hand in hand with science. Today, in the atomic age, it is merely suicidal.

30. It is apparent that the conflict between science and the church, on which the Victorian Age reached a smug but workable compromise, has not really been resolved. The present role of science in the conduct of society suggests that when this compromise becomes unworkable through doubt about the essential humaneness of man, science is powerful enough to shove religion aside and ignore the questions that a responsible church must raise.

Appendix I (continued)

Q-Sort Cards

31. The costs of scientific research today have tied science so closely to the purposes of elite groups in society that it has abandoned most of its critical and skeptical function. When you are dependent on tax exemptions and foundation grants in order to get your work done, you get to be pretty careful never to catch Truth in embarrassing commerce with Mars or Mammon.

32. Science cannot really claim to have solved the social problems that stem from its own institutional framework. The very categories of thought into which the scientist must fit his data are colored by middle-class values. Data that do not fit his categories will tend to slip off his IBM cards and be edited out of his publications as sloppy.

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Appendix II

Directions for Card Sort

(Each subject was supplied with a set of 32 shuffled cards and this set of directions at the beginning of his appointment with the Interviewer.)

Suppose that a young friend of yours is seriously considering becoming a scientist and is discussing his plans with you. Because of the importance of such a decision, you wish to make sure that he considers the drawbacks to a scientific career as well as whatever positive reasons he may have, before committing himself finally.

On these cards, you will find stated thirty-two different reasons why a person might hesitate to become a scientist. You are to decide which of these to bring to his attention. Please read all the cards through thoughtfully. Then, having read them through:

1. Select the eleven cards that make most sense to you, setting the rest aside.
2. From these eleven, select four that seem to you more important than the remaining seven.
3. From these four, select the one card that seems to you most important of all.
4. Returning to the twenty-one cards that you set aside, again select eleven, this time choosing those that seem relatively misleading or distorting or for any reason wrong or inferior to the others.
5. From these eleven, select four that seem to you more misleading or worse than the others.
6. From these four select the one poorest or most misleading card of all.

You should now have the cards arranged symmetrically in piles of 1, 3, 7, 10, 7, 3, and 1, along an axis indicating the significance you would attach to them.

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